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"SNAIL-LEECHES," WITH A MONOGRAPH OF THE BRITISH SPECIES.

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(*With Two Plates.*)

THERE are many objects familiar to the eye of the aquarian naturalist with which, however, he may be almost entirely unacquainted, so far as relates to their habits and structure. It is impossible to turn up a number of small stones in a brook, or to examine many aquatic plants and submerged pieces of wood, without discovering specimens of animal life, which, perhaps, from their not very prepossessing appearance, we are almost disposed to neglect. We are greatly delighted should we meet with a piece of water-weed to which are attached numerous *Melicertæ*, and should our pocket-lens reveal the presence of a few colonies of *Stephanoceros*, we are almost wild with delight, but the writhing horse-leech and *Nephelis* we are inclined to look upon with no pleasurable feelings, and should decidedly object to the introduction of such nasty, slimy creatures to the other tenants of our aquarium. And yet the graceful method in which many leeches swim is well worthy our admiration, while the study of their anatomy will amply repay any amount of patience bestowed upon it. The different species of snail-leech, to which I am now introducing my readers, do not generally present externally any very captivating appearance, and yet they are objects of especial interest to the naturalist, from the circumstance that some of this family do literally deposit their eggs upon the underside of stones and leaves, and sit upon them until they are hatched. Again, from the great transparency of the young ones, it is, comparatively speaking, an easy task to make out a good deal of the structure and internal anatomy, while the facility with

which specimens may be obtained renders continuous investigations easy.

The snail-leeches are properly separated from the true red-blooded leeches, such as *Hirudo medicinalis*, *Hæmopis sanguisuga* (horse-leech), *Nephelis* (whose oval capsules with their contained eggs are common at this time of the year on every aquatic plant), *Trochetia* and *Aulastoma*, which form the family of *Hirudinacea* (see Grube's *Die Familien der Anneliden*, Berlin, 1851). The snail-leeches, which have colourless blood, and differ in several important particulars from the true leeches, form, with the genus *Piscicola*,* a distinct family, to which, from their possessing a peculiar characteristic proboscis capable of exsertion, the appropriate name of *Glossiphonidæ* (syphon-tongued) was proposed by Dr. Rawlins Johnson in 1816. Before the researches of Dr. R. Johnson, the Glossiphons were classed promiscuously with various other leech-like animals, to which the generic name of *Hirudo* was given. This appropriate term has been unfortunately allowed to give place to that of *Clepsine*, proposed, I believe, by Savigny in 1827. What the derivation of the word may be I am unable to discover.

The snail-leeches inhabit fresh water, and no marine species have as yet been found. In every brook, in every pond, and almost in every ditch, certain species occur. As a rule pure water is preferred, but *Glossiphonia bioculata* and *G. hyalina* are by no means particular in this respect. The normal form of a snail-leech when at rest may be described as follows:—Body dilated and depressed; upper surface more or less convex; the under surface is flat and concave; the anterior extremity, which in a few species may be said to form a distinct head, is always less obtuse than the anterior; the mouth, which is situated nearly at the apex of the anterior extremity, is transversely elliptical, two-lipped, and furnished with a strong muscular protractile proboscis; eyes variable, according to the species, there being either one, two, three, or four pairs, generally of a black or deep claret colour, disposed in two longitudinal series, but slightly converging towards the anterior extremity; in some individuals the anterior pair are wanting, and the order of arrangement is confused. The hind sucker is always much larger than the front one; indeed, the mouth, forming the anterior sucker or *acetabulum*, is no true sucker at all.† The colour of the different species, as well as the consistency of the body, varies; some are grey with rows of dull spots, others minutely speckled, others marked with golden dots; some are

* I include *Piscicola* with the Glossiphons on the authority of Grube, who recognizes a proboscis in that genus, but I am not satisfied that *Piscicola* is possessed of this organ.

† *Piscicola*, however, has the anterior sucker fully developed.

semi-crustaceous, and one species soft and flabby; some of the species when taken out of the water roll themselves up oniscus-like (Pl. 1, Fig. 4), while one has the habit of putting out its tongue or syphon when handled (Fig. 9). These creatures live upon the juices of various aquatic animals, such as small worms, gnat-larvæ, and molluscs. The proboscis is inserted into the body of the victim, and the nourishing liquid pumped out. All the species are oviparous, depositing their ova upon submerged bodies, and sedulously incubating them, as in *G. complanata*, *marginata*, and *tessellata*, or else they carry them about within the cavity of the abdomen, formed by the folding inwards of the margins, as occurs in *G. bioculata* and *hyalina*. Observers having noticed the young completely closed in by the folds of the abdomen, have erroneously described certain kinds as viviparous. The whole family is oviparous. The curious incubating habit already mentioned appears to have been first noticed by Baker, who, I think, observes that the young frequently leave their mother's pouch and return again to their shelter. I have not witnessed this latter circumstance. None of the family are capable of swimming, so far as I have observed; all the members locomote by attaching one extremity of the body to the ground or the surface of leaves, etc., and by drawing the other extremity up to that point. The closely allied genus, *Piscicola*, common as a parasite on fish, both swims and moves in the manner above described.

Having made these general observations, let us glance at some of the parts belonging to the internal structure of these creatures. The species *G. complanata* is perhaps as good as any to operate upon. Having put our subject under the influence of chloroform, we place him in a small shallow trough of fresh water, and by means of a couple of pins, one at either extremity, fasten him down on his back. The form of the mouth is readily seen under the lens; with a little skilful manipulation, we shall see that the mouth is connected with the characteristic proboscis by means of a delicate membranous œsophagus, with which it is continuous, and by which it is included: when the animal protrudes this tube the membrane is drawn over it, like the unfolding of a glove from the finger. In form this tube is cylindrical, minutely segmented at the apex, and sometimes bulbous at the extremity (Pl. 2, Fig. 2); its reticulated muscular structure is seen in Fig. 3. The juices which constitute the food of the snail-leech proceed down this tubular organ (which is protruded at the time it is feeding, and which is fixed in the soft integuments of the animals preyed upon), and flow into another delicate membrane situated at the bottom of the tubular bulb, and thence into the stomach.

This organ consists of a branched membrane attached to the body walls; it is furnished with five or seven pairs of pouches, or gastric cæca. In these pouches it is evident that the juices must be assimilated. An Italian writer (De Filippi) says he has noticed special channels of communication between these cæca and the blood-vessels through which the imbibed blood of the victims passes almost directly to the vascular system (?). The general form of the stomach of a snail-leech may be seen in Plate 2, Fig. 1; the dark-coloured contents of which (as seen in Plate 1, Fig. 1) clearly enough reveal the branching cæca—the last pair of which is much larger than the others, and is always directed downwards towards the posterior extremity.

The intestine, like the stomach, is divided into branching cæca, four being the normal number. The intestine ends in a perforation situated on the dorsal surface, at the point of juncture between the posterior sucker and the body.

The circulation in these animals, though clearly seen, especially in young specimens, is difficult to ascertain precisely. It may be enough to remark that the heart is represented by a dorsal vessel extending throughout the entire length of the leech; there is also a corresponding ventral one. The circulating fluid, which is colourless, is propelled by the contraction of the dorsal heart into a number of radiating vessels, which carry it to a couple of lateral canals, one on each side of the animal.

In the red-blooded leeches it is the lateral vessels which contract, in the Glossiphons the dorsal one acts the part of a heart. The blood is no doubt oxygenated by coming in contact with the air contained in the water, principally in the attenuated margins of the body, which are beset with innumerable small blood-vessels. A snail-leech may often be seen to create currents of a fresh supply of water by attaching its suckers to the glass vessel in which it is confined, and by undulating the intervening portion of the body in a vertical direction.

The nervous system is simple, and the entire cord may with care be dissected out. It consists of a double chain of nervous matter with ganglionic knots occurring at irregular intervals (See Plate 2, Fig. 7).

The ovary (Plate 2, Fig. 6) consists of a double sac-like lobe,* situated in the anterior portion of the body. The enclosed vitelli are attached to a long twisted cord, *funiculus* (Fig. 5), but fall from it before exclusion. The mode in which the eggs are deposited, and their development, is full of interest, and readily observed at the proper season of the year.

* A single lobe only is represented in the engraving.

At the time when the Glossiphon is ready to deposit her eggs she may be observed to be very uneasy, twisting herself about in a peculiar manner, and contracting her body violently into one position; by and by a thin jelly-like secretion encircles that portion of the body from which the vitelli come out; simultaneously with the formation of this surrounding belt of jelly, the vitelli are excluded in small masses at a time; they are thus contained within this secretion, and the animal, by a particular twist of the body, extricates its head and neck from the gelatinous belt, which, with its contained vitelli, now forms an egg and adheres to the side of the glass. After an irregular lapse of time the same performance will be again gone through, and a second egg, or batch of vitelli, will be deposited, and a third, or fourth, etc., at intervals. If the reader will refer to what I have said (INTELLECTUAL OBSERVER, No. xi., 1862, p. 357) on the subject of the *Nephelis* engaged in laying her eggs, he will be able to compare the one phenomenon with the other. A viscid secretion, which ultimately forms the vitelline membrane, or egg covering,* occurs both in *Nephelis* and *Glossiphonia*; the vitelli are inclosed after the same manner within this secretion, and both animals extricate themselves from the surrounding belt pretty much in the same manner. But the secretion, which in both forms a vitelline membrane,† remains in *Glossiphonia* unchanged; it is a thin gelatinous fluid, adhering by a pedicle to the substance to which it is attached; while in *Nephelis* the secretion undergoes considerable change, instead of retaining the consistency of thin jelly, it gradually alters, at first assuming a firmer character, and at length, after the lapse of a few days, becoming quite leather-like in its nature.

The *Nephelis*, it will be remembered, uses its mouth, and fixes the egg (capsule and vitelli) to some object; but the Glossiphon appears to press its ova to the sides of the glass by the abdomen. After all the eggs are laid, the Glossiphon—those species, that is, which exhibit this habit—settles down to a quiet domestic life, continuing at home, and nursing her embryo fry. The changes in each vitellus may be readily noted each day, the process of segmentation marked, and the gradual development into a young and perfect Glossiphon watched with delight and instruction. The usual time which a snail-leech occupies in her incubating task is about ten days, but it may be longer or shorter; the embryo drop out of the vitelline mem-

* This viscid pellucid membrane represents the *chorion*; the round grains, which are about the size of a large pin's head, are the *vitelli*; both together forming an *ovum*.

† Dr. Johnson is in error when he states that the vitelli of the snail-leeches are not inclosed in a capsule, which, however, from its transparency, is not readily discernible.

brane—which one may often see in the form of a thin particle of jelly adherent to bodies taken out of ponds—and attach themselves to the under surface of the mother. And a very curious sight it is to see the young fellows popping out their heads on all sides, accompanying their "maternity" wherever she goes, remaining thus tied to their mother's apron strings for six or seven weeks in some cases.

I do not know an instance of any other animal so low in the scale of creation that exhibits so great care for its young ones. Amongst Crustacea, some of the *Isopoda* have been observed to exhibit much affection for their young brood, receiving them, after temporary wanderings, back into the cavity fitted for their protection; and the female *Coccus* deposits her eggs, and then dies as she sits upon them. But not all the species of *Glossiphonidæ* are "sitters." Some, instead of depositing their eggs on foreign bodies, retain them, as I have already remarked, within the cavity formed by the folding inwards of the sides of the abdomen. This is the case with *G. bioculata*, and *G. hyalina*. The number of young ones which the snail-leech produces varies; as few as three and as many as thirty may be contained within each vitelline membrane. The clusters, or ova, also vary considerably in number. So far as I have observed, the large gelatinous species *Glossiphonia tessellata* is the most prolific. Some deposit their eggs as early as April, others in June and July. Upon *G. bioculata* the smallest of the family, is almost invariably found a curious cup-shaped plate. It is situated on the front part of the animal, about the twelfth segment. What its use may be I have no idea; it open out at the upper surface, and is quite characteristic of this species (Pl. 2, Fig. 4). It is very common to see a group of infusoria parasitic upon this membranous plate (Fig. 8). Several species have been described as belonging to this family, but there is much uncertainty about some of them. I will now give descriptions of the following, all of which, perhaps, are true British species:—*Glossiphonia complanata*, *G. bioculata*, *G. tessellata*, *G. marginata*, *G. hyalina*, *G. verrucata*, and *G. eachana*. I am well acquainted with all except the two last named.

G. complanata.—Body, when at rest, almond-shaped, narrowing suddenly at the anterior extremity; back with four or five rows of conical transparent papillæ or tubercles—the two largest and most distinct forming a row on either side the medial axis of the body—and having two dark lines down its middle; these two medio-dorsal lines, which are constant in this species, although sometimes indistinct, are either uninterrupted throughout the entire length of the body, or an even succession of spots; rings, about sixty in number; eyes, six

(hence the specific name of *sexoculata* of some authors), of a triangular form, occupying the fourth, fifth, and sixth segments; sometimes the first pair are wanting, or the whole six are confused and irregularly placed; colour, variable; body, firm, and semi-crustaceous, rolling up like an oniscus when handled; posterior sucker large, and sometimes marked with light-coloured rays; length, from half an inch to nearly an inch (not extended); stomachal cæca, six pairs, the first five being nearly at right angles to the longitudinal axis of the body, the sixth larger, and directed downwards, but not reaching to the posterior sucker; proboscis dilated towards the base, then again narrowing.

VARIETIES.

A. Body greenish, densely sprinkled with minute dots of a dark colour; back marked with large golden spots, arranged in longitudinal lines, which disappear towards the anterior extremity; each spot is formed of a number of small granular spots; the body, as seen under the microscope, is marked with faint reddish patches.

B. Body brown, with very delicate close striæ, both longitudinal and transverse.

C. Body more elongated anteriorly than in the other forms, and softer; the animal less readily assumes a rolled-up form when handled. Colour a light olive brown, the two medio-dorsal lines being less distinct than in the other form of the species. Eyes four, five, or six, nearly always confused. Oval sucker, when extended obtusely, triangular; margins of body more sharply crenated than in the other forms. This variety seems to partake both of the characters of *G. complanata* and *G. bioculata*; it is more slug-like than the normal form of the species. The normal form of *G. complanata* is abundant everywhere, hiding under stones and leaves, and within the stems of aquatic plants. It is prettily marked on the dorsal surface. It deposits its ova, which are sometimes of a delicate pink, on submerged bodies in the months of April and May.

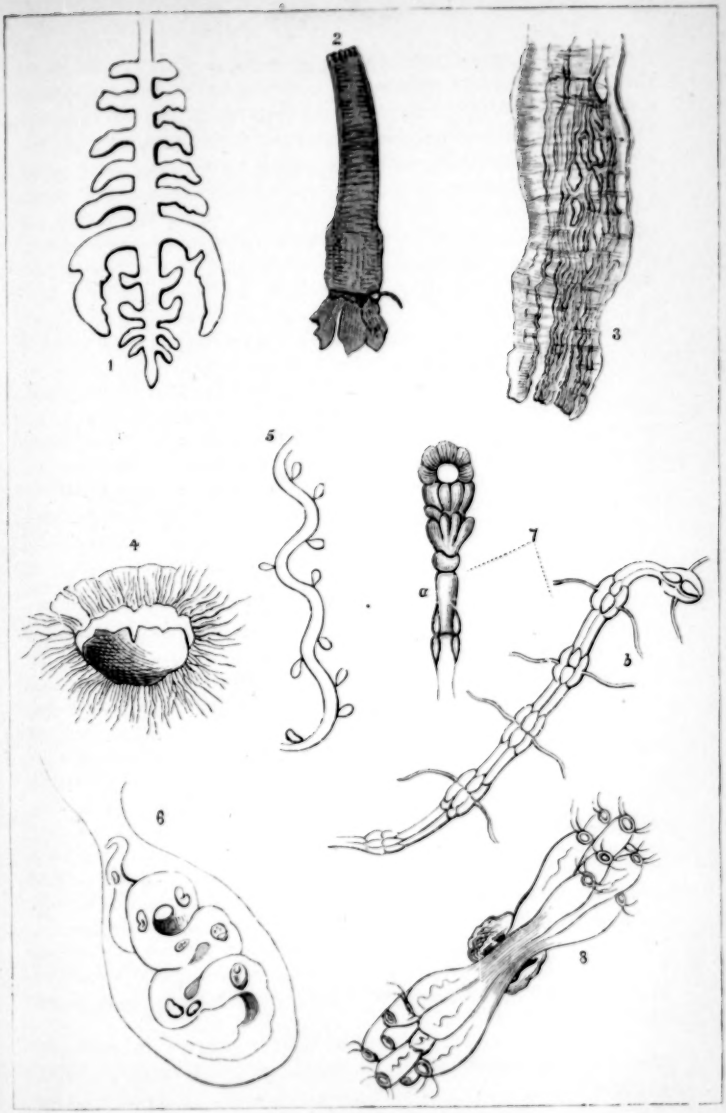
G. bioculata. Body more attenuated anteriorly than the last species, and considerably smaller; colour light brown, or greenish grey; soft; rings distinct, about sixty-four in number, deeply and sharply serrated at margins; eyes two in number, black, situated on about the third ring. Back thickly dotted with minute semiconfluent dark spots, more sparingly towards the margins; a regular row of these spots on each side the axial line of the body, leaving a clear space between the rows. Proboscis distinctly notched at the apex, often protruded to the extent of nearly half its length when the animal is taken out of

the water. A brown, semicircular, coriaceous plate is seen about the twelfth ring, its convex side pointing towards the posterior extremity, opening through the integument of body externally; this plate is sometimes rudimentary. Ova attached to the abdominal surface, the centre of which forms a deep cavity by the folding together of the margins; this is best seen when the animal extends itself in locomotion. Stomachal cæca six pairs, anterior pair divided upwards. This leech often keeps its posterior part doubled up in a heap, and draws it along in this position. This is the smallest of the *Glossiphonidæ*, and is extremely common. It produces its eggs in April, May, and June; the young attaching themselves by their posterior suckers to the abdomen. Length about five lines.

G. tessellata.—The largest and most leech-like of the family. Body, when at rest, oblong, anterior extremity being more rounded than in other species; colour, dull olive green, with about five rows of light yellow spots arranged longitudinally; the spots on the margins are much the largest. Body nearly an inch in length; gelatinous; posterior sucker large; oral sucker sub-triangular, forming, when the animal extends itself, a hollow cup-shaped cavity. Eyes, four pair; the first pair slightly converging. Deposits its ova (June and July) on submerged bodies, and sits upon them; the pellucid vitelline membranes, which are large, may often be found adhering by their pellicles to leaves, stones, etc., after the embryos have left them. The young of this species is very beautiful, being in its earliest stage of a pinkish hue; but this delicate appearance changes to a dull olive, marked with longitudinal lines of white spots. Müller has very correctly observed that this species is so variable, according to age, that the individuals can only be recognized as belonging to the same species by continual observation. It is the most active of the family, and moves about with great celerity. It is generally considered rare; but although certainly far from common, I have little doubt that careful searches after this species would be rewarded with success. It is not uncommon in the Shropshire Union Canal, from whence I have obtained several specimens. I have also found it in weedy pools. It is the most prolific of all the family; as many as 200 young ones may be counted attached to the mother.

G. marginata.—This is a rare but very pretty little Glossiphon; it was added by myself to the English fauna in 1860. I give the description of this species as recorded in the *Annals and Magazine of Natural History*, No. 28, April, 1860, p. 249.

"Body, when at rest, nearly elliptical, but narrowing towards the anterior extremity, capable of great elongation



SNAIL LEECHES.

Glossiphonidæ.

1, Digestive apparatus of a Glossiphon.
2, Tubular proboscis, mag. 20 diameters.
3, Portion of ditto, highly magnified.
4, Cup-shaped plate of G. bioculata.
5-6, Ovary.
7, Nervous system. *a*, Cephalic ganglia. *b*, Portion from body.
8, Parasites on cervical plate of G. bioculata.

when it assumes a linear form. Back, when arched, showing the rings distinctly, marked longitudinally with fine regular rows of light yellow dots, equidistant, and thinly sprinkled with smaller dots of the same colour, the centre row alone extending nearly the whole length of the animal. Margins light coloured and transparent, having at intervals two narrow dull-coloured parallel lines, which are at right angles to the axis of the body. Ground-colour of body, claret. Oral sucker constricted at the base, sub-triangular or lozenge-shaped, forming a well-defined head, its extremity being almost transparent. Head with a light claret-coloured patch on either side, giving it, if examined without the aid of a lens, a truncate appearance. Eyes, four, arranged in two longitudinal series, converging anteriorly; the posterior pair much the largest. Posterior sucker very large, round, with about twelve distinct radii. Stomachal cæca seven pairs, with three smaller ones in front; the former bifurcate, and nearly at right angles to the axis of the body; the seventh pair immediately bending downwards and extending to the base of the posterior sucker. Colour of the cæca, a deep green. Length, about six lines."

This species bears in form some resemblance to *G. tessellata*, but it is smaller and not gelatinous. It deposits its ova in June and July, on submerged bodies, and sits upon them. The ova are generally yellow, and the whole abdominal surface of this species at the breeding season is of the same colour. The young attach themselves to the mother, and are carried about by her, as in the rest of the family. *G. marginata* is rare; on one or two occasions I have found it in the Shropshire Union Canal. It is very interesting to note the marks that appear to connect different species of the leech family one with another. I have already observed that *G. tessellata* approaches in some particulars to the character of a true *Hirudo*, or red-blooded leech; in *G. marginata* we meet with some curious resemblances to an annelid of the same family, but of another genus, namely, *Piscicola*. Like *Piscicola*, *G. marginata* is often seen extended in repose, being attached by its posterior sucker, and holding out its body at right angles with the point of attachment. *Piscicola* is often found parasitic upon fish. I have found hundreds of specimens on the dead body of a pike; and it is well known to all fishermen that live fish, such as trout, carp, etc., are often troubled by these worms. Partially parasitic also in its nature is *G. marginata;* if placed in the same vessel with a fish, this Glossiphon will immediately attach itself thereto, and remain there for days together. I have little doubt that it feeds upon the mucus secretion and blood of the fish. I have never seen any of the Glossiphons swimming, but I should not be surprised to find *G. marginata*

an exception to the rule, and to resemble *Piscicola* in this particular as in others.* One point, however, in which the last named worm differs from every species of Glossiphon, consists in its mode of reproduction. The *Piscicola*, after depositing her oval cocoons, leaves them, and the young never attach themselves to the parent.

G. Hyalina.—The most transparent of the family, and widely distributed. Body when at rest oval and much dilated; colour of a transparent amber; back sprinkled with numerous granular orange spots; eyes, three pair, arranged as in *G. complanata.* Anterior extremity pointed; posterior abruptly obtuse; gastric cæca six pairs, anterior smallest, and divided upwards, the rest gradually increasing to the last pair, which immediately bends itself towards the posterior extremity. It carries its ova (June and July) within the abdominal pouch, like *G. bioculata.* This species is very inactive, and rolls itself up when handled. After feeding the stomachal cæca become of a bright vermilion, which, seen through the transparent body of the leech, gives it a beautiful appearance. Müller did not exaggerate when he applied to this Glossiphon the title of "*Vermiculus splendidissimus.*"† The specific name of *Hyalina* will enable the student to identify this Glossiphon at a glance.

G. verrucata.—I know nothing of this species. It is said to differ from *G. complanata* in having seven pair of gastric cæca, instead of six, and in having a body softer than that species.

G. eachana.—Found only in L. Neagh, Belfast, and described by Mr. W. Thompson in the *An. and Mag. of Nat. Hist.*, vol. xviii. (1846). His description is as follows:—"Body oval, anterior portion not dilated into a distinctly formed head, back smooth, margin slightly crenulate, eyes eight; stomachal lobes subpinnate, prevailing hue hyaline. The size commonly extends to nine lines." Mr. W. Thompson says of this species, "The glassy transparency rendered the vessels of the digestive system, which were of a fine dark red colour, very conspicuous, and owing to the jagged outline of the series of lateral lobes, etc., the creature was so extremely beautiful that it might be compared to an arborescent agate." Mr. Thompson's figure somewhat resembles *G. tessellata*, but it appears to be a distinct species.

Several other kinds of *Glossiphonidæ* have been named as claiming distinct specific recognition; but the descriptions are in some cases very vague, and in others they clearly point to

* *Piscicola* is often said to be incapable of swimming; this is a mistake, it swims readily. M. Moquin Tandon says, "Ces Hirudinées ne nagent point." (*Monograph*, p. 293.)

† *Verm. Terrest et Fluviat*, ii. p. 50.

some of those I have described above, either in the young or mature state.

In conclusion, I may recommend the study of this interesting family to the readers of the INTELLECTUAL OBSERVER, as being one which will apmly repay them for their trouble, and which may result in giving us further information as to the number of species which may fairly be supposed to represent this family in the British Isles.*

THE EXHIBITION OF MINIATURES AT SOUTH KENSINGTON.

BY W. M. ROSSETTI.

THE art of miniature-painting is one of the processes of water-colour art, differing from the ordinary processes in proportion to the small scale of its productions. The word "miniature," which has come to mean "diminutive," or "small," appears, indeed, to have had originally no such signification, but to spring from the Latin *minium*, or white-lead, the pigment mostly used in the early book-paintings and initial-designs called likewise "miniatures," but now more commonly "illuminations." But, however this may be, positively or comparatively small size is an essential of miniature-painting, as we now apply the term; and some modification in artistic handling is the needful consequence. The colours, instead of being washed in, or laid one over the surface of another, have to be dotted or streaked on with the point of the brush, or, in the studio phrase, "stippled," or "hatched." Some miniatures are executed entirely on this plan; in others, it is confined chiefly to the flesh-painting. As in most other directions, however, modern intolerance of the restrictions proper to particular forms of art has transgressed the limits of size natural to miniatures; and, some quarter of a century ago, a fashion, almost unexampled till then, arose of painting fair-sized figures, or largeish half-figures, under the name of "miniatures." Now this fashion has almost gone out again, and for a too conclusive reason—miniature-painting has itself almost gone out, hustled off the field by the ease, the semi-infallibility, and the cheapness, of photography. It tends fast to becoming a lost art, and will be absolutely lost in a few

* Some of the figures which illustrate this article are copied from the late Moquin Tandon's *Monographie de la Famille des Hirudinées*. Paris, 1846. They will facilitate identification, being good representations; the other figures were originally drawn from specimens.

years—in England, at least—unless the tide of taste should somewhat turn. That this *should* turn is most highly desirable; and there can be little doubt that the art, if culpably allowed to die out now, will have to be revived at some future time, under the disadvantages native to all such revivals. No beautiful art, no sphere of development for human skill, ought ever to be permitted to come to an end. Miniature-painting *is* a beautiful art, and people will begin to rediscover that when they get tired of being represented, on the small scale fit for gifts and *souvenirs*, only by mechanically produced and indifferently coloured photographs. We wish all possible honour and development to photography, but not a monopoly fatal to the miniature or any other fine art.

We have said that miniature-painting is a water-colour process; and so it almost universally is, upon the materials most peculiarly appropriate to it, which are vellum, card, and, in more recent times, prepared ivory. This last, which now counts as the miniature material *par excellence*, was not introduced into use until about 1685. Even on this material, however, oil-colour has been occasionally used, not with good effect (as in the heavy, lightless series by Andrew Robertson, a once highly admired practitioner, in the South Kensington Exhibition); and, in a wide acceptation of the term, various other sorts of pictures or designs are accepted as miniatures. Mr. Samuel Redgrave, the compiler of the catalogue for this exhibition, says, "Miniatures may be painted or drawn on any material, and with any material used by the artist, and in every style of art. It was deemed best, in the interests of the exhibition, to accept all such works as were drawn to a small scale, and were, in respect to manner, of a miniature character, except paintings on porcelain." Thus the exhibition includes the singularly-perfect enamels of Petitot, and those of his successors, which is obviously reasonable. We cannot quite agree, however, in the admission of ordinary oil-portraits of moderate size—say from a foot to a foot and a half—painted upon canvas or panel, and of similar-sized water-colours or pencil-drawings upon paper. To us it appears plain that these are not, in any fair sense of the term, miniatures; and the admission of a few of them seems to suggest that, if any at all, there ought to be many more in proportion. They are here also necessarily hung at a height which, slight as it is, prevents them from being examined with entire satisfaction, considering their limited size.

We pause a moment to describe, in the words of Mr. Redgrave, the process of the enamel art above referred to, which is, of course, a wholly different thing from miniature-painting, and more analogous to porcelain painting. "The

art of enamelling is of great antiquity and uncertain origin. . . . About the beginning of the fifteenth century, by an improved process, painted enamels became applicable to miniature-portraits; an art which was certainly derived from France, but was not brought to much perfection till towards the middle of the seventeenth century. In 1632, a goldsmith, Jean Toutin, who was skilled in the use of transparent enamels, produced a variety of colours which, when used upon a thin ground of white enamel, vitrified in the furnace without any change of tint. These colours were applied in the same manner as water-colours used on vellum or ivory; they were the materials of the first miniaturists, and, a few years later, they enabled the great Jean Petitot to carry the art to its highest excellence. They consisted of metallic oxides, with fluxes of vitrifiable substances, chiefly silica and borax, both fusible at a heat capable of being resisted by the metal ground, whether gold or copper, on which they are to be used. It is also essential that these materials should be of a character to adhere firmly to the ground, should possess the transparency or opacity required to give finish to the artist's work, and maintain, after fusion, a smooth, clear, vitreous surface. The colour produced results either simply from the colouring material used, or from the chemical combination of that material with the flux."

Miniature proper (to which we now revert)—the painting in water-colour with the point of the brush upon card, vellum, or ivory—has been a specially British art. The names of some foreign artists, as for instance Holbein, stand indeed in the first rank of the art; but, perhaps, the most entirely typical specimens of it, executed by artists who were nothing or hardly anything save miniature-painters, are those left to us by our countrymen, Nicholas Hilliard, Isaac and Peter Oliver, and Samuel Cooper, in the sixteenth and seventeenth centuries; by Cosway at the end of the eighteenth and the beginning of the nineteenth; by his finest successor Ross; and in the latest development of the art by Thorburn and Wells, living artists who have survived the art whereby they acquired their fame, or at least have had to "give it over" in its now moribund condition, and occupy their talents otherwise. Mr. Redgrave speaks of "the inimitable Samuel Cooper," seeming to imply that that master of the Cavalier and Roundhead period was the prince of all miniature-painters. Recognizing his singular excellence, we yet think that the still earlier painters, Hilliard and Isaac Oliver, represent the very finest condition of the art. The miniature method of execution, small dainty touches upon the smoothest of surfaces, indicates the artistic qualities most suitable to such works. These are delicate precision, clearness, and harmonious nicety. The smaller the works are the better,

else there is no reason for such smallness of handling. Similarly, they deal best merely with a head and shoulders, for there is not adequate room for more; they should eschew dark shadow, for a small work much shadowed is in total effect a blot; they should aim at the utmost simplicity of pose and motive consistent with elegance, and stopping short of formality, for more of vividness and variety requires space for its proper development; they should be bright and decorative, for they belong to the *bijou* order of art; and, being thus, and comparatively devoid of shadow, they are none the worse, but rather the better, for a certain general look of flatness. Card or vellum, as of old, is probably a preferable substance to ivory for miniature-painting, as the excessive smoothness of the latter favours overloading of colour, or else produces want of solidity. The reader who knows the qualities whereby the old sixteenth-century miniatures are specially distinguished from their successors, will perceive that those miniatures are the most thorough embodiment of all the æsthetic and executive virtues we have here attempted briefly to summarize, and that the productions of after times, up to our own, have more and more deviated from this ideal, increasing in size and decreasing in whatever separates the miniature from other forms of art. In fact, the comparison between Hilliard and Cooper rests on much the same basis as that between Holbein and Vandyck, as portrait painters on a larger scale; with this difference, that, while it may be questioned which of these admirable oil-painters developed the style better suited for large work, there can be little doubt that the Holbein-like style is the more applicable to the small scale and special execution of miniatures. Cooper may, however, be regarded as having extended though not improved upon the art, and as dominating all subsequent developments of it up to the time when Cosway, a painter of great ability and elegance, struck the keynote which has prevailed from that date to this. He is the Reynolds, and to some extent the Lawrence, of miniature art, doing his portraiture "with an air:" he produced and represents the transition from the work of the eighteenth to that of the nineteenth century. The latter is known to all of us, and has already been sufficiently referred to.

The Exhibition of Portrait-Miniatures which opened at the South Kensington Museum on the 1st of June, got up by the Educational Committee of Privy Council, with the assistance of an influential advising body, is probably the richest in number and quality ever organized in this or even in any country. It contains 3081 works, lent by a large number of owners, and representing the art chiefly as practised in the United Kingdom, but not by any means exclusively so. Of

course the exhibition has a double and emulous interest; the interest of the works as artistic productions, and the interest, historical or other, of the persons pourtrayed. Scores and scores of the most famous men and women of the past three centuries and a half are here brought visibly and vividly before us; in many cases we can trace their progress from childhood or adolescence to old age, and see the stamps set upon them by time and chance, by passion and self-interest, by self-control and abnegation, by intellect and folly. We shall now proceed, with but little attempt at classification and still less at exhaustiveness, to pick out a few bricks from this beautiful Babylon. Our selection will be guided by the double interest we have just adverted to—that of the painting itself on the one hand, and of the sitter on the other; the interest, however, is so frequently fused, the best sitters eliciting the highest skill of the finest artists, that we shall not make any formal division between the two classes of examples. We may add that the compiler of the catalogue explains that the names of both artist and sitter are, with few exceptions, given as stated by the owners of the miniatures, and that the catalogue cannot therefore be appealed to as authority on this point—a circumstance we may regret, but can hardly complain of under the particular conditions which affected the present collection. We must also apologize to the owners for omitting, with a view to space, their names in our enumeration of the works: for this detail of great practical importance we must refer the student to the catalogue—the choice for ourselves being between the omission of owners' names, and that of some portraits which fairly claim to be specified.

BRITISH PORTRAITS BEFORE AND DURING THE TUDOR PERIOD.

Edward IV. and others. Water-colour, or what is usually termed an illumination, on paper; this must be the oldest work in the exhibition, or rather, as explained in the catalogue, a copy of such a work. It is inscribed as follows: "Earl Rivers presenting his book, and Caxton his printer, to Edward IV., the queen, and prince. From a curious MS. in the Archbishop's Library at Lambeth. The portrait of the prince (afterwards Edward V.) is the only one known of him, and has been engraved by Vertue among the heads of the kings. The person in a cap and robe of state is probably Richard Duke of Gloucester, as he resembles the king, and as Clarence was always too great an enemy of the queen to be distinguished by her brother. The book was printed in 1477, when Clarence was in Ireland."

Henry VII. "Represented holding four heartsease flowers

in his crossed hands; a female hand is approaching his breast, above which is the inscription, *A corde cor traho.*"

Henry VIII., 1526, by Holbein. A three-quarter bust portrait.—By the same (No. 1392). Oil. Fair, but not particularly fine for Holbein.—By the same (No. 2082).—Henry VIII., about thirty, ascribed to the same. Neither the quality of the painting, nor the evidence of dates, favours the assumption that this work is by Holbein. That painter did not come to England till 1526, whereas Henry was thirty years of age in 1521.

Catherine of Arragon, by the same. From Strawberry Hill, and stated by Walpole to have been "given to the Duke of Monmouth by Charles II." Fine.

Anne Boleyn, ascribed to the same. Not rightly so ascribed, we venture to affirm.

Jane Seymour, by the same. Crayons tinted.—By the same, inscribed "ano 25."

Anne of Cleves, by the same. Oil. This is substantially the same as the well-known portrait of Henry VIII.'s "Flanders Mare;" it seems to have been re-painted to some extent. The face is heavy and not attractive.

Thomas Howard, third Duke of Norfolk, by the same. Oil. A mild look characterizes this Duke, the father of the poet Sanrey, and remembered in history partly through his good luck in the death of Henry VIII. the day before that which the monarch had appointed for the Duke's execution.

Alicia, wife of Sir Thomas More, by the same. Admirable.

Sir Nicholas Poyntz, by the same. Good, but rather too minute, and perhaps a questionable Holbein. That painter included Poyntz in the series of portraits at Windsor Castle.

A Lady, by the same. "Anno ætatis suæ, 23: her coat of arms is affixed to the case." Somebody ought to trace out this coat of arms, and tell us who the lady was. It is a quiet, simple, composed face, not beautiful, and looking some few years older than the recorded age; and, as a work of art, amazingly perfect and true, perhaps the very finest thing in the exhibition. The owner, Mr. J. Heywood Hawkins, may be congratulated upon possessing, of its class, one of the finest objects in the world.

The Earl of Kildare, by the same. Oil. Excellent.

The Countess of Kildare, by the same. Oil. Also very fine.

Edward VI., 1547, ascribed to the same. This is in a fine miniature style, with clean-cut touch, the colour very flat and sunken. One may safely say, however, that it is not by Holbein, who died in 1543, according to recent evidence which appears indisputable, and has not, indeed, we believe, been disputed.

The Protector Somerset, by Hilliard, 1560. A posthumous portrait, or perhaps a copy of a portrait from life, the decapitation of the Protector having taken place in 1552.

Queen Mary I., by Sir Antonio More. Oil.—By Luis de Vargas, 1555. Oil. A very fine head-and-shoulders portrait, of fair size.—Another, author anonymous (No. 1282). Appears to our eyes of more than doubtful authenticity. The costume belongs rather to some twenty or thirty years after Mary's death, and the type of face suggests a princess of the Austro-Spanish family.—By Holbein. At an early age, perhaps sixteen, when, according to the evidence of this portrait, the princess had pale golden hair.

Edward Courtenay, Earl of Devon, the suitor regarded with some favour by "Bloody Mary." "He is represented in a white shirt, with open lace collar, holding a chain or bracelet, and locket, the latter being suspended round his neck; behind him, in the background, rise flames." This last is a very curious detail in a fine miniature.

The Regent Murray, "An. 1566, Æta. 33," by Antonio More. Oil. Very fine.

Queen Elizabeth, by Hilliard. A somewhat broader face than in most portraits.—Another, anonymous. Seems about the age of nineteen, with a boyish look.—By I. Oliver. A very pretty miniature, with an almost Chinese absence of shadow.—By Hilliard, in a very richly jewelled dress and lace ruff. This is one of those old miniatures in which the almost entire absence of colour from the flesh is a salient peculiarity, and a defect. We scarcely know how far this may be the intentional manner of the artist, or how far it may be the effect of time and exposure. As Mr. Redgrave says in his catalogue, "It is truly painful to see how many fine miniatures have been exposed to the sun, till all their colour has been absolutely burnt out, while others have equally suffered from damp, or from the absence of the most ordinary protection required for works of such minute delicacy." Certain it is, however, that this facial pallor is often found associated with sufficiently full tints in the costume, as in the miniature of which we are now speaking.—By Zucchero, "A Young Lady, supposed to be Queen Elizabeth as Princess." This gives a front and a back view of the head, and is, in all respects, most charming. We wish it were possible to "suppose" the original to have been Elizabeth, but the evidence of dates makes such a suggestion quite absurd. When Elizabeth was about sixteen, the age to which these portraits may be referred, in 1549, Federigo Zucchero was a boy of six; when Zucchero came to England in 1574, Elizabeth was a woman of forty-one.—By Hilliard, at about sixty years of age.—A pro-

file, painter anonymous. "It is stated on the back of the miniature, that this was the only portrait of her taken in profile." Age somewhere towards thirty-six. This is a grand head, more massive in type than in most of the portraits.—By the same, about the same age, or rather younger. A fine portrait.—Ascribed to the same, a portrait of fair size, towards the age of forty-five, in which Elizabeth is represented crowned and decked with jewels.—By the same, "mounted in an oblong snuff-box; a small and elaborate miniature, representing the queen in a black dress *semée* with pearls, rubies, etc., and wearing the usual high lace ruff, from which pearls are pendent." A very small miniature, and a perfect specimen of about the best possible style of the art.—By the same, "Ano Dni. 1564, Ætatis suæ 25." The hair here is of a bright copperish tint, more strong than in most portraits.

Mary, Queen of Scots. "1565, Ætatis suæ 24." This is a vulgarish-looking portrait, and, we should say, not recognizable as intended for the fascinating queen.—After Cornelius Jansen. Enamel. Said to have been taken in Paris before the death of her first husband Francis II.—The same, inscribed "la Royne Dauphine." Panel. An excellent work, showing Mary in her girlish loveliness. Perhaps, however, one would scarcely recognize it as being meant for her.—The same, half-length, in a black hat over a lace cap. Graceful in her stiff dress.—After I. Oliver's original in the Royal Collection. Has more of the look of a Dutch Frow than we are accustomed to ascribe to the Queen, yet not unpleasing.—School of Clouet. Oil. "This portrait, purchased at Paris in 1821, represents her just after her marriage (1558) with the Dauphin."—The same, "an elaborately finished miniature, representing the Queen with light auburn hair, wearing a crown, with jewelled collar and badge, in a rich dress with full sleeves slashed down the arm. She is playing on a lute, and is seated in a high-backed chair, each arm of which is surmounted by a globe and crown—one being that of the Dauphine of France; the other may be intended for that of England." This is a very charming portrait, combining a genuinely royal aspect with a certain poetic or romantic quality, as of one of the ladies in the Decameron.—By Hilliard, 1579. A good record of the Queen in her thirty-eighth year, showing more solidity of facial form than in most portraits.—The same, painter anonymous. "Face to the left, wearing a close ruff, and black veil falling behind." A neat miniature, much stippled. As it stands, it hardly appears to be a contemporaneous work, but may probably be such a work re-touched.—An oil-portrait, painter anonymous. A very pleasing likeness, both girlish and queenly, at about the age of seventeen.—Mary and her son

James, with Edinburgh in the background, ascribed to Hilliard. —Ascribed to the same, Mary, with a somewhat gipsy-like expression. "Given by Mary to one of her maids of honour on the [which?] occasion of her marriage; from whom it descended to her grandson, the second and last Earl of Middleton, who died 1695."—The same, painter anonymous. "Small full-length portrait, holding a crucifix in her right hand, and a book in her left; beside her, on a table, is a crown and sceptre, and in the field to the right are painted the royal arms of England. Inscribed 'Maria Stuart, anno 30.'" A notable and pretty little portrait. We may add that this series of miniatures only confirms, what is well known to investigators, that the divergences between the various so-called portraits of Mary Stuart are extremely serious.

Robert Dudley, Earl of Leicester. Younger than in most of the portraits, say about thirty-four years of age, with hair already thin.

Robert Devereux, Earl of Essex, by I. Oliver. Unfinished. —The same, 1588. Oil on copper.

William Cecil, Lord Burleigh. A small full-length.—Another, age about forty, with a knowing, penetrating glance.

Thomas Howard, fourth Duke of Norfolk, by Sir A. More. Oil. Inscribed "Ætatis 25, 1562." This is the Duke of Norfolk, son of the beheaded Surrey, and himself beheaded under Elizabeth. The portrait is a fine one, like a Holbein.

Sir Francis Drake, by Hoskins.—By Hilliard, inscribed "Ætatis suæ 42, Ano Dni. 1581." If 1545, the date of birth ordinarily given, is correct, Drake can only have been thirty-five or thirty-six in 1581. This portrait bears some resemblance to one which is catalogued as Sir Philip Sidney.

Sir Walter Raleigh, "Ætatis suæ 65, A.D. 1618."—The same, by I. Oliver. Looks hardly more than some twenty-one years of age, the face less long than in some other portraits.

Henry Wriothesley, Earl of Southampton, "the friend and patron of Shakespeare," 1616, by the same. This portrait shows a well-made face, in early middle age, with a slightly Jewish expression. There is nothing in it conspicuous enough to favour the theory that the friend whose personal beauty is so enthusiastically praised in Shakespeare's sonnets can have been Wriothesley.—By P. Oliver. A very aristocratic head; somewhat too much so perhaps, as if the blood had run pure so long that it had begun to thin. One may notice a certain resemblance to Charles I.

Sir Philip Sidney, ascribed to I. Oliver, inscribed "Anno Domini 1586, Ætatis suæ 19." Sidney was properly thirty-two years of age in 1586, the date of his death. This portrait presents light curly hair and a wry mouth; perhaps it is not

to be implicitly trusted.—The same, painter anonymous, inscribed "Ano Dni. 1582, Ætatis suæ 28." A very unprepossessing portrait, and unlike the accepted head of Sidney. The hair here is black, or at any rate very dark, and the cast of features the reverse of aquiline.

A Lady, in the costume of the early part of Queen Elizabeth's reign, by Zucchero. Oil. Admirable.

Lord Hunsdon, by Hilliard, 1605, Cousin and Master of the Horse to Queen Elizabeth. An admirable example of the style of this golden period of the miniature art.

(To be continued.)

THE WEATHER.

BY A. S. HERSCHEL, B.A.

"CHANGEABLE as the weather," "fickle as the wind," are proverbs whose truth is confirmed in so many instances that no meteorologist will venture to deny them. To interpret the frowns of the weather, and to predict its storms, is at best his thankless task; but to trace its fundamental laws to all their irrevocable conclusions evidently transcends the powers of human thought. The laws themselves are not many, nor difficult to understand, but the immense diversity of circumstances under which they are applied, makes it impossible to follow them out to their actual results. An outline only of the general laws can be presented, and every reader of the INTELLECTUAL OBSERVER will doubtless be able to add some jot or tittle to the store.

Torricelli, a friend and intimate of Galileo, who flourished about the middle of the seventeenth century, discovered that the earth, and its envelope the air, are surrounded by a vacuum. This, which is called the "Torricellian vacuum," is imitated whenever water is attempted to be raised by suction to a height exceeding thirty-three feet. The celebrated experiment of Torricelli was to show that the same vacuum is produced when mercury is attempted to be raised by suction in a tube to a greater height than thirty inches. In fact, in either of the two supposed cases, the air and the water, or the air and the mercury, balance each other by their unassisted weight, and the height of the atmosphere is made known by the height of the column of the fluid.

The height of a column of mercury at freezing temperature, which balances the average weight of the atmosphere at the sea-level at Greenwich, is 29·953 inches. Thirty inches of

mercury (in round numbers), at freezing temperature, approach so nearly to the average pressure, that this pressure is called the standard pressure of the air. In rising to a greater height above the sea, or if air becomes lighter at any place, or a portion of it flows off from the top of the atmosphere, the pressure becomes less, and the column of mercury becomes shorter. From this circumstance an instrument constructed on these principles, and known after its inventor as the "Torricellian tube," is called a barometer (*βάρυς, heavy; μέτρον, a measure*), because it measures the weight of the atmosphere (whether in rest or motion) over any place where it is used.

Air at standard pressure, and at the temperature of freezing water, is 10,486 times lighter than the fluid mercury by which its weight is measured. The height of the atmosphere, it might be supposed, is therefore just so many times greater than thirty inches; or, in other words, five miles all but sixty-two yards. This height of a "homogeneous atmosphere," as it is called, is, however, only imaginary, because it is well known that air is an elastic fluid, which presses on everything (at constant temperatures) in proportion to its density. The densest of the atmosphere is, therefore, below, and the rarest part above. So far as barometric observations have extended, the standard pressure of the atmosphere remains the same, and air does not appear to leave the earth. A definite limit to the atmosphere, therefore, probably exists, but at what distance from the earth, whether at 100 or 150 miles, or upwards, is not known, although certain circumstances lead us to suspect about that height.

The law of rarefaction in that part of the atmosphere which need be considered in meteorology is, however, this, that while the height increases in arithmetical, the pressure and the density diminish in geometrical progression. Consider, for example, the decimal fraction 0·999, etc., continued *ad infinitum*, to represent by unity the whole weight of the atmosphere in any column from the level of the sea. The amount of it contained, by weight, in the first ten, twenty, thirty miles, etc., above the sea, is represented by the first one, two, three, etc., figures of this decimal. This is, in fact, not merely an illustration, but a near approximation to the truth. Thus at a height of ten miles above the sea nine-tenths of the atmosphere are left below, and one-tenth part of it only remains above. Ten miles compared to the diameter of the globe is no thicker than the roughness of an egg, but even in this small depth the lower half contains twice as much atmosphere as the half above. The sensible atmospheric covering of the globe, therefore, transcends very little the tops of the highest

mountains, yet in this thin covering all the wonderful changes of the weather are produced.

In the early part of the present century Sir Humphrey Davy pointed out among the first, that dry air, at whatever time, or in whatever part of the atmosphere it is collected, consists of nearly twenty-one parts of oxygen and seventy-nine parts of nitrogen, by volume, in an invariable proportion. This fact was also confirmed by Gay Lussac in his balloon ascents, and is a point of special importance in physics, where the specific gravities of gases are referred to that of dry air as a standard.

Besides oxygen and nitrogen, the atmosphere contains a very variable amount of aqueous vapour. One and a-half per cent. of this gas, by volume, may be taken as an average proportion between the extreme of dampness and dryness of the air. Carbonic acid gas is another variable constituent of the atmosphere, and its volume, on an average, is little more than a twentieth part of that of aqueous vapour. According to the theory of Dalton, these gases are all mixed together, without any preference among themselves.

With the exception of hydrogen and ammonia among the gases, and the vapours of a few volatile ethers, aqueous vapour is the lightest known gas. The following table of specific gravities will make this clear.

Table I.—Specific gravities of certain gases in the atmosphere :—

Hydrogen	0·069
Ammonia	0·597
Aqueous vapour . . .	0·624
Nitrogen	0·971
Dry air	1·000
Oxygen	1·106
Carbonic acid gas. . . .	1·529

A mixture of air and aqueous vapour is, therefore, comparatively buoyant; but a mixture of carbonic acid and air, or "choke-damp," as it is called, is heavier than common air, and therefore remains *in situ* at the bottom of shafts and wells, whilst moist air rises to the summit of the atmosphere.

By an admirable course of experiments at the Royal Institution, Dr. Faraday showed that a number of gases—chlorine, for example, among the elements, and carbonic acid gas among the compound gases—are converted by high pressure into liquids. The liquids again resolve themselves into gases when the pressure is relieved. Aqueous vapour comports itself in every respect like a gas, of which the liquid form is water.

An instrument well adapted to illustrate this peculiar property of aqueous vapour is the cryophorus. This is an instrument composed of two glass globes connected together by a bent glass tube. The whole is completely exhausted of air, and the globes are partly filled with water. In this condition the cryophorus resembles a kind of "water-hammer," for when the water is emptied from one globe into the other, it rattles with a noise like falling ice. To use the instrument, the emptied globe is placed in a freezing mixture of pounded ice and salt. The other globe, containing water only, is exposed freely to the air. A brisk evaporation commences immediately from the surface of the water, and the vapour passing over to the bulb imbedded in the freezing mixture is condensed. While water is converted into vapour, a large quantity of sensible heat is rendered latent. If this is not supplied from without, the effect of evaporation is to lower the temperature of the bulb, and at last to freeze the water it contains. On this account the instrument is called a cryophorus (*κρύος, cold; θέρω, I carry*); because cold, in effect, is carried from the freezing mixture to the other bulb. The principles illustrated by this experiment of the cryophorus are those of the condensing steam-engine, and of the exhausted evaporating pans employed by refiners for crystallizing sugar. The boilers in these machines are supplied with external heat, and the condensers are kept cool by running water.

At high temperatures great pressure is required to reduce a gas to its liquid form, or, in other words, the greater the temperature of a liquid the greater is the pressure of its vapour. Boilers are thus replenished by vapour, of a pressure corresponding to the temperature of the water. The space within the boiler is in this case said to be *saturated* with vapour. At a high pressure (and temperature) great mechanical effects can be produced. In the cryophorus, above described, and in performing distillation at low temperatures, the saturating pressure of the vapour is also low.

Maury has actually described the atmosphere as "incomparably the greatest steam-engine with which we are acquainted." The temperature of the air at the equator is 83° Fahrenheit, and the mean temperature at the coldest places near the Poles is little above the zero point of Fahrenheit's scale. A similar depression of temperature is found in ascending 50,000 feet into the air. The atmosphere therefore more nearly resembles an immense cryophorus, or vast distilling apparatus, of which one boiler is placed at the equator and its condenser at the poles, and another boiler is placed at the base and its condenser at the summit of the atmosphere. Were the air at rest, a universal cloud-canopy would envelope the earth by reason

a continual process of vertical and horizontal distillation, and the beneficial rays of the sun would thus be excluded. But the pressure of the vapour is very small (seldom exceeding an inch of mercury at the equator), and the powerful impulses of the wind are sufficient to convey to every part of the globe the salutary changes of weather which it requires. Thus it happens that dry air and fine weather are everywhere imported from the polar quarter of the globe, and rain and cloud from the opposite direction by the wind.

The atmosphere is accordingly far from being everywhere so saturated with vapour as if it were at rest. To determine the proportion of its moisture to that of complete saturation, or, in other words, the *relative humidity* of the air, at all times and places, is the special object of hygrometry. Different instruments called hygrometers (*ὑγρός, moist; μέτρον, a measure*) have been invented for this purpose, but with only partial success. Daniell's hygrometer (or different forms of this hygrometer), and Mason's hygrometer, or the wet and dry bulb thermometers, yield the most satisfactory results. The first of these instruments fixes at once the "dew-point" of the air, or the temperature at which its moisture begins to be deposited in the form of dew. This is the temperature to which air must be reduced in order to saturate it completely with the vapour it contains. The pressure (or amount) of its vapour is then easily ascertained from a table of saturating pressures, as well as the additional amount necessary to complete the saturation of the air. Mason's hygrometer consists of two ordinary thermometers, the bulb of one of which is kept constantly wet, and shows the "temperature of evaporation." The bulb of the other thermometer is dry, and registers the temperature of the air. From the readings of this instrument a set of hygrometrical tables were constructed by Mr. Glaisher, which afford, under all circumstances, the required conditions of the air. These are—1st, its dew-point; 2nd, the pressure of its vapour; 3rd, its relative humidity (before described); 4th, the weight of water contained in a cubic foot of the air; and 5th, the additional weight of water required to saturate a cubic foot.

It has been remarked by Redfield, one of the first meteorologists in America, that very brisk winds are often limited vertically to very thin sheets or layers of the air. "Few facts," he writes, "in meteorology are more worthy of our attention than the stratiform character and vast horizontal extension of the aërial currents in different parts of the globe." This characteristic property of the atmosphere, by which its extensive ventilating system is rendered complete, undoubtedly forms one of the most striking features in meteorology. In describing the vast circulation of the trade winds, the consideration of

its effect cannot be omitted; but even in the course of ordinary observations the horizontal arrangement of the clouds, and their cross-currents, one above another, afford daily means of verifying the horizontal direction of the wind.

Suppose a current of air to descend from above, with the velocity of an ordinary gale of wind, which is sixty miles an hour, from an extreme height of ten miles above the earth. In ten minutes it would arrive at the surface of the earth. The elastic pressure of its mass would at the same time be increased about tenfold. A very ordinary experiment, and one recently improved by Dr. Tyndall, may be taken to illustrate the change that would thereupon occur in the intruding mass.

When air, confined by means of a piston in a tube, is suddenly compressed to a tenth or a twentieth part of its original volume, the heat developed by the sudden compression, it is well known, is such that tinder, punk, or amadon attached to the end of the piston is instantly ignited. Such an instrument is called a fire syringe. In its new form the tube is made of glass, and a small portion of combustible gas is included with the air. A bright and vivid flash at the moment of compression then gives ocular demonstration of the violence of the heat. Lest the circumstances of the wind should not be considered as adequately represented by the conditions of this experiment, it may be calculated that air submitted to a tenfold pressure must have its temperature elevated to the extent of fully a thousand degrees Fahrenheit. This is therefore what would take place in the descending mass, which would be rendered buoyant by the heat developed, and would return rapidly to the summit of the atmosphere by the force of gravity alone.

In a less extreme case, when wind is only slightly deflected from its horizontal course either upwards or downwards by any interruption, it quickly returns (by the force of gravity) to its accustomed level, on account of the change of temperature that attends its change of elevation.

Main currents of the air are therefore horizontal, and violent currents of the air, in a vertically ascending or vertically descending direction, are, from the nature of the case, impossible.

The mainspring of ventilation in the air is the ascensional force of air and vapour imparted to wide tracts of the atmosphere by the ardent rays of the sun, scattered again in other spaces by radiation from the earth. The focus of the sun's action describes a diurnal circle round the globe, which is in the equator at the time of the equinoxes, and at either tropic at the solstitial seasons of the year. The latter circles receive their name of tropics from the fact that the sun, although it

remains longer over these circles than over any other circle of the globe, returns at these times to seek the other tropic at the other side of the equator. In the frigid zones of the globe, within the Arctic and Antarctic circles, the sun remains for days and months together invisible beneath the horizon. To illustrate the intensity of the opposite causes operating in these different regions of the globe, two kinds of thermometers are employed, called solar and terrestrial radiation thermometers. The former has a blackened bulb, surrounded by an exhausted globe of glass, and it occasionally marks 50° F. above the temperature of the surrounding air. The latter is an ordinary minimum thermometer, and is exposed at night upon the grass. When exposed on wool or feathers it has been observed by Mr. Glaisher at Greenwich to fall as low as 30° F. below the temperature of the air. In both cases the temperature of the air is that of a thermometer in the shade suspended four feet above the ground. This measure in some degree indicates the extent of the causes whose contrast from the equator to the poles produces the prevailing direction of the wind.

The temperature of the air at the equator is 83° Fahrenheit, nearly without vicissitudes throughout the day or year. In higher latitudes the temperature is not only less, but it is subject to two oscillations, one depending upon the seasons and the other upon the alternation of day and night. The following table exhibits the average value of the first oscillation, at Greenwich, from the mean of fifty years (1814—1863), above and below the mean temperature of 49°·03 Fahrenheit.

Table II.—Annual curve of mean monthly temperatures at Greenwich, for fifty years (1814—1863) :—

	Deg.		Deg.		Deg.
Jan.	— 12·1 (F.)	May	+ 3·9 (F.)	Sep.	+ 7·6 (F.)
Feb.	— 10·3	June	+ 10·1	Oct.	+ 1·2
Mar.	— 7·3	July	+ 12·8	Nov.	— 5·8
April	— 2·8	Aug.	+ 12·2	Dec.	— 9·2

The table shows that the seasons are not distributed according to the quarters of the year, but there is a range of nearly 25° (F.) between January and July, which are respectively the coldest and the hottest months. *December*, *January*, and *February* compose the Winter, and *June*, *July*, and *August* compose the Summer season. Spring and Autumn occupy the intermediate months. A comparison of the temperature of every day for the same number of years shows that, at Greenwich, the 8th of January and the 15th of July (St. Swithin's Day) are respectively the coldest and hottest days on the average of fifty years.

The daily oscillation of temperature, at Greenwich, from the average of five years (bi-hourly observations, 1841—1845), is represented by the following table, above and below the mean temperature for the period.

TABLE III.—Diurnal curve of temperature at Greenwich for five years (1841—1845) :—

	Deg.		Deg.
1 h. a.m.	— 3·4 (F.)	1 h. p.m.	+ 5·1 (F.)
3 h. „	— 4·2	3 h. „	+ 5·8
5 h. „	— 4·8	5 h. „	+ 4·4
7 h. „	— 3·9	7 h. „	+ 2·0
9 h. „	— 1·2	9 h. „	— 0·6
11 h. „	+ 2·3	11 h. „	— 2·3

About an hour before sunrise (5 h. a.m.) is the coldest time, and three o'clock in the afternoon is the hottest hour of the day. The average daily range is 10°·6 (F.). These hours and the daily range vary very considerably in the different months. Wherever observations are continued at a particular hour of the day, special tables are therefore required for every month, to deduce the "mean monthly temperature" from the mean temperature observed at any hour. Where, however, self-registering maximum and minimum thermometers are used, a simpler method is to ascertain the average highest day temperature, and the average lowest night temperature for the month. The arithmetical mean between these quantities is always *higher* than the true mean monthly temperature of the air by the amount contained in the following table.

TABLE IV.—Correction to be applied subtractively to the arithmetical mean between the average highest day temperature and the average lowest night temperature for any month, observed with self-registering thermometers, to obtain the true mean monthly temperature :—

	Deg.		Deg.		Deg.
Jan.	— 0·2 (F.)	May	— 1·7 (F.)	Sep.	— 1·3 (F.)
Feb.	— 0·4	June	— 1·8	Oct.	— 1·0
Mar.	— 1·0	July	— 1·9	Nov.	— 0·4
April	— 1·5	Aug.	— 1·7	Dec.	— 0·0

Twelve mean monthly temperatures having been obtained by either mode, the average of all is the mean temperature for the year. This is found to be a very constant quantity, although the annual range of temperature is subject to very considerable variations.

The mean yearly temperature of the air having been determined by observation at different places of the globe, lines of

equal temperature, or "Isotherms," as they are called (*ἴσος, equal; θερμός, hot*), are drawn round the globe, giving equal weight to every place. It is then found that the temperature of the air on the western coasts of Europe is higher, especially as compared with the eastern coasts of Asia and America, than the ordinary temperature for the latitude. The same excess is also observed on western, as compared with eastern coasts in every part of the world, but the annual range of temperature is less. Thus, from Gibraltar to Norway the range varies between 15° and 35° (F.). From Florida to Labrador, on the opposite coast of America, the annual range of temperature varies between 30° and 50° (F.). At Pekin, on the eastern coast of Asia, in the latitude of New York, the range of temperature is 60° (F.), but near Vancouver's Island, in higher latitude, on the western coast of North America, it is not so great by half, or less than 30° (F.).

In this general feature of the weather, the predominating winds play an important part, as will hereafter be explained. Not only do they elevate the temperature, but, bringing with them clouds, the land under their influence neither loses nor acquires its heat so rapidly as in countries less affected by their action.

On the borders of the Great Sahara, at sunrise in December, it is no uncommon occurrence for ice to be found upon the shallow pools. In our own climate hoar-frost is occasionally produced in June. On the parched plains of Bengal ice is artificially prepared by exposing water at night in shallow vessels to the sky. Thus Jacob, in Scripture, speaks to Laban:—"In the day the drought consumed me, and the frost by night." The history of Gideon's fleece receives support from the copious dew found by travellers on the sides of lakes, rivers, and the sea in Palestine and Arabia. These facts are very illustrative of the rapid radiation from the earth under calm and cloudless skies. Dew and hoar-frost are thus produced.

On undulating ground and verdant slopes the cold air from the inclines collects on calm nights in hollow basins at their feet. The line of contact with the warmer and moister air above is marked by a thin horizontal sheet of fog, producing from above the winding appearance of a river, or the wide and waste appearance of a lake. These radiation fogs, as they are called, are raised and dissipated at sunrise by the heat of the sun, whose rays in their turn produce by day an exactly opposite effect.

Air at the surface of the earth exposed to an unclouded sun becomes charged with heat and vapour. It is rendered buoyant, and rapidly ascends to a height where its excess of

vapour is discharged in clouds. Dome-shaped, cumbrous-looking masses are produced, at a height of 4000 to 8000 feet above the sea, called *Cumulus* clouds, from their pillow-like appearance. At Quito, and at other places on the equator, these clouds first make their appearance in the morning. They increase in size and numbers till the afternoon, and at the same time subside in height until the sky is completely overcast with a species of clouds called *Cumulo-stratus*, from which rain is immediately discharged in torrents. With the disappearance of the sun these clouds subside yet further, and cumulo-stratus then collects itself at evening into horizontal stripes of clouds, called *Stratus* from their level distribution. These clouds only accompany fine and sunny weather peculiar to a dry condition of the air.

In mountainous countries, a great variety of clouds is produced among the upturned currents of the air. The well-known "caps" upon the summits of certain mountain-peaks—for example, the Mam Tor, or Shaking Mountain, in Derbyshire, the Matterhorn in Switzerland, and the Table Mountain at the Cape of Good Hope—give these mountains the appearance of active volcanoes in perpetual eruption. Being driven to visit a higher and a colder level, the currents of wind discharge their moisture for a time, which they again resume on descending the opposite declivity of the mountain. Near to the Table Mountain, a secondary cap is even formed, at a considerable distance, by a secondary ripple of the wind. The influence of mountain-slopes is, however, confined entirely to the precincts of their valleys. This is most apparent in the fact, that some mountain-ranges are subjected to perpetual rain, while the plains in their immediate neighbourhood are free. In Cumberland, from the summit of Skiddaw, three thousand out of five thousand clouds were reckoned by Crossthwaite to occur below the level of the mountain, whose height is 3150 feet above the sea. The remainder, or by far the smaller number, occurred at greater heights. The reverse would probably be observed on the surrounding level land, for there high clouds are the rule, and those of lower elevations the exception.

The loftiest clouds of all are the slender whisps of Cirrus—"mares' tails," as they are generally called—whose streaks occur at heights of more than 20,000 feet above the sea. Cirrus is the natural forerunner of a southerly wind. Should its streaks be tangled, and their edges sharp and well-defined, they give short notice of the coming wind. In general they are diffuse, and Cirrus gradually overspreads the sky with a misty, gauze-like veil, called *Cirro-stratus*. The various appearances of halos, burrs, mock-suns, and mock-moons, are seen in this cloud in perfection, which also gives a

fiery hue at sunset to an apparently cloudless sky. Its height is 15,000 or 20,000 feet above the sea. At a lower and more advanced stage of the southerly current, *Cirro-cumulus* is formed, and the well-known appearance of a "mackerel-backed sky" is produced. Cirro-cumulus is the immediate precursor of the wind, or of rainy weather, according as its outlines appear sharp and oily, or the reverse. It changes by insensible degrees into cumulo-stratus, whose ragged masses sail across the sky, or settle into thick and rainy weather according to the moisture of the air. Between cirro-cumulus and cumulo-stratus, a quantity of fleecy clouds are often found; and in the direct light of the sun, the vivid hues of the mackerel's skin, as described by Sir John Herschel (*Meteorology*), are sometimes reproduced. It also forms a corona of highly-coloured circles round the moon, especially in unsettled conditions of the weather, when a south-west current veers towards the north, and northerly winds are felt along the ground.

A cloud is called *Nimbus*, or rain-cloud (as its name implies), when, from its lower surface, it precipitates rain, snow, or hail. Local clouds of this kind are seen both in mountain-valleys and in the plains, and are never absent when thunder and lightning are produced.

As it is not intended in these articles to enter into practical details, the particular difficulties of rain-guage measurements in connection with this subject, now attracting much attention, must be passed over in silence, and the subject of rain, hail, and snow will be deferred to a chapter on the winds.

In the foregoing paragraphs, a knowledge of the construction and use of simple instruments only has been assumed—such as the different forms of the thermometer. An acquaintance with the standard form of barometer will, in the same manner, be found a sufficient introduction to the subject of the winds. Attention must, however, be paid to two principal corrections of the barometer, without which it fails to indicate the atmospheric pressure. The first of these corrections is that for temperature of the mercury, and of the brass scale (in perfect instruments), as shown by the "attached thermometer." The other is for the height of the instrument above the sea. The height of the mercurial column, "corrected to the freezing temperature of water, and reduced to the level of the sea," represents the pressure of the atmosphere at any place; and observations of this kind can only be consulted for comparison with one another. For this purpose, Lowe's *Barometrical Tables* are extremely useful, and more abundant materials are contained in the *Meteorological Tables*, published by the Smithsonian Institute of America.

AIDS TO MICROSCOPIC INQUIRY.—No. VII.

Hairs of Plants.

It is a very common thing for the possessors of microscopes to neglect objects of beauty and interest which are readily accessible, and thus not to derive from their instruments the pleasure and mental profit they can afford. Those who have even a few square yards of town garden, or who have access to ordinary plants, may derive much gratification from the examination of the hairs of plants.

The hairs of plants are cellular growths springing from the cuticle; so that, if the plant possesses a solid woody stem, the hair, however hard in character, may be entirely removed by pulling away a portion of the cuticle beneath it, and without touching the solid stem. Thus hairs, even when prickly, are distinguished from true spines, such as grow upon holly stems, and remain after all the integuments have been removed. In its simplest form, a plant-hair consists of a single straight tube of small dimensions; but jointed hairs, composed of cell added to cell, in linear prolongation, are very common; and so are hairs of a still more complicated structure, beautifully branched, and presenting star-shaped, or other agreeable, forms.

In vegetable structure we continually notice that certain cells are strengthened by a layer or layers of internal deposits. Cherry-stones, vegetable ivory nuts, and innumerable other substances, are composed in this way. These strengthening deposits may be of a character allied to woody tissue (*sclerogen*), or may consist of mineral matter, such as the silex found in the outer layers of straw, canes, etc. A hair stiffened in this way becomes a bristle, or a stiff scale. Ordinary hairs are soft, delicate structures, with fluid contents, the rotation of which may be seen with a sufficiently high power. Cabbage-leaves offer good specimens of single hairs, conical in form. Beautiful star-shaped hairs cover the leaves of the Alyssum, common in all gardens; and, in fact, plants by the dozen might be named in which the hairs are well worth examination. We shall select a few we have picked from very accessible plants.

First, if we take an ivy-leaf—a young bright green one being the best—and turn it with the under side upwards, we have a beautiful object for an inch or two-thirds object-glass. We see groups of hairs springing from a common base, and stretching out somewhat like the arms of a star-fish. This object should be viewed by reflected light, and then some of the hairs, removed with a portion of the cuticle on the point of

a penknife, can be placed in a drop of water, and examined with a quarter or a fifth as transparent objects.

A young green pod of a sweet pea is another good object. To the naked eye it is obviously hairy, and when a strong light is thrown upon it, and it is viewed with a three-inch objective, the effect is very fine; each hair is seen to rise from what looks like a little globe of crystal, which flashes in the light, and contrasts beautifully with the bright green cells of the peascod. When we take off a little piece of the cuticle with its adherent hairs, and view it with a power of one or two hundred linear, we find that what looked like little transparent globes under the lower objective, are delicate, somewhat conical elevations, composed of many transparent cells, and surmounted each by a long hair.

Another superb low power object may be found in the under surface of a foxglove leaf, thickly set with jointed hairs, amongst which little insects roam, as larger animals do in forest glades.

Our next object of this class shall be selected from an old-fashioned plant, easily obtained, and whose sweet scent preserves its place as a common favourite—we mean lavender. Take a fresh clean leaf of this plant and shave off a little of the down on its surface with a razor or sharp knife. Place the down on a slide in a drop of water, cover with thin glass, and magnify about sixty linear. The hairs are then seen to be beautifully branched in star patterns. With polarized light and selenite object-holder they are elegant objects, lit up with rose and purple light when the prisms are in one position, and shining like silver when they are in another. These hairs are well worth mounting in glycerine jelly or some such material.

Exquisite stellate hairs, strengthened with a silicious deposit, are found on the leaves of the *Deutzia gracilis*, a common greenhouse plant, covered with graceful white flowers in the spring. They are admirable polariscopic objects, not as well known as the leaves of the *D. scabra*, which is less frequently met with and scarcely more interesting. A piece of the leaf should be mounted in glycerine jelly, or any fluid good for the preservation of vegetable tissues. The effect of polarized light on this object is to give it the appearance of stars formed of coloured gems on a richly tinted ground.

It is very common to find hairs on plants swollen into little globes at their tops, and containing a special coloured secretion. Hairs of this description are called *glandular*, and they often form objects of remarkable beauty. If the flower of the common snapdragon (*Antirrhinum majus*) is torn open, groups of yellow tipped hairs will be seen on the inside of the corolla. These should first

be viewed without disturbing them, by using a low power, and illuminating them as an opaque object. They will be seen to be tubes terminating in globular heads, and more or less filled with a bright-coloured fluid. A few of the hairs may then be cut off with a fine, sharp pair of scissors, taking a delicate slice of the cuticle of the corolla with them. These hairs, examined under a power of from 200 to 1000 linear, will be found covered with minute elevations all up their tubes and over the expansion at the top. Although the terms cuticle and epidermis are commonly applied to the whole cell-wall of a hair, it will be found that a true epidermis, or outer covering, may be separated by acids from the real skin, if we may use the term. In the case of these hairs, nature seems to have blown out the true epidermis in little bubbles of elongated form, and hence the irregular appearance which their surface presents. Some of these snapdragon corolla hairs are spindle-shaped, and blown out with more or less irregularity. They are all interesting microscopic objects, and the splendid yellow colour of their contents does not seem to be injured by glycerine jelly. Another pleasing object will be found on the stems of the pretty wild flower, "Herb Robert," the hairs of which have exquisite ruby balls at their tips.

The phenomena of cell rotation may be seen in hairs, and Mr. Wenham has traced it in a great variety of plants. It requires careful illumination for its display, and a higher power than suffices for showing the movement of the coloured sap globules in Anacharis or Valisneria. The hairs to be examined should be removed without injuring them, by tearing off a portion of the cuticle from which they spring. They should be immersed in a drop of water, and, if necessary, slightly warmed by blowing hot air upon the covering glass, which may be effected by means of a glass tube heated by a spirit lamp. Dr. Carpenter says "the nature of the movement in the hairs of different species of plants is far from being uniform. In some instances the currents pass in single lines along the entire length of the cells, as in the hairs from the filaments of the *Tradescantia Virginica*, or Virginian spiderwort. In others there are several such currents which retain their distinctness, as in the jointed hairs from the calyx of the same plant. In others, again, the streams coalesce into a network, the reticulations of which change their position at short intervals, as in the hairs of *Glaucium luteum*, whilst there are cases in which the current flows in a sluggish uniformly-moving sheet or layer. When several distinct currents exist in one cell, they are all found to have one common point of departure and return, namely, the "nucleus," from which it seems fairly to be inferred that this body is the centre of the

vital activity of the cell."* This "nucleus" will be easily recognized as a stationary mass of protoplasm.

The interest derivable from these inquiries will be much increased by paying attention to the botanical characters of plants, and observing in succession several members of the same family, noticing both resemblances and differences. Botany is, from its profusion of hard words, a very alarming-looking study; but a very moderate amount of trouble will enable any one to learn enough of the principles of classification to ascertain, with the help of a good book, the family genus, and generally the species to which a plant belongs. It is a bad plan for any one not studying under a good botanist, whose verbal explanations can at once remove difficulties, to begin with costly and elaborate text-books. A simple elementary work, like Spencer Thomson's *Wayside Weeds*,† will form a much better introduction; and when a few easily-obtained plants have been examined as he directs, the student will be prepared to profit by the *British and Garden Botany* of Mr. Leo Grindon,‡ which is the easiest and most convenient book for general reference that has been produced. The works we have named are both cheap, and their possession will greatly augment the quantity of amusement and instruction to be obtained by means of a microscope. The writings of our great botanists, Lindley, Hooker, Babington, etc., will be all the better appreciated if studied after some preliminary knowledge has been gained.

The interest arising from the study of plant hairs will be assisted by a regular method of viewing them. First *in situ*, with a low power, so that their general form, grouping, and situation, with respect to veins, stomata, etc., may be seen. Then a minute examination with higher powers, and lastly the employment of polarized light.

* *The Microscope and its Revelations.* Third Edit. p. 409.
† Groombridge and Sons. 1864. ‡ Routledge.

SUBMARINE TELEGRAPHY.

BY RICHARD BITHELL, B.SC., PH.D.

No attentive observer could spend an hour in the examination of any of the commonly-used electric telegraphs without discovering that there were *three* distinct parts of the apparatus on which the engineer is called upon to direct his energies, and which in turn may task his highest skill. These parts are—

I. A battery—voltaic or magnetic—as a source of electric power.

II. Conducting wires—by means of which the electric fluid is conveyed from one spot to another more or less distant.

III. Instruments—that is, pieces of apparatus; by means of which the action of the fluid on the conducting wire may be made evident to the eye or ear.

Every telegraphic system contains these three parts, and each in turn has been an object of the electrician's profoundest study and most earnest solicitude. In all cases the *first* of these parts is a matter of primary importance, and in the infancy of telegraphic science much difficulty was felt in securing batteries of sufficient power and constancy—the latter quality being essential to the proper working of the system. Owing to the amount of attention and experience which have been brought to bear on this part of the apparatus, batteries of various kinds have been devised, which answer their purposes sufficiently well to meet all the requirements of telegraphy in its present stage of development. In the transmission of currents over long distances however, and especially in marine telegraphy, great difficulties are met with in the construction of the *second* part of the system, namely, the conducting wires —difficulties so great as to offer a wide field of improvement to those whose business or taste may lead them to engage in the study. But in the organization of central stations, and especially in such as have to transmit or receive messages in great number, the *third* part rises into importance, and the question is how to construct instruments which shall communicate signs to the ear and eye with the greatest promptitude, rapidity, and precision. In the observation and consideration of any form of telegraph, therefore, it will be necessary to glance at each of these three portions of the apparatus, while one or the other may claim in turn a greater amount of attention, according to the purpose to which the telegraph is to be applied, or the special object which we have in view.

Telegraphs are commonly, though rather loosely, designated

according to the supposed excellence of one or more of the three parts above named, or according to the purpose for which they are intended. Thus we have Needle telegraphs, so called because their indications are made by the deflections of a magnetic needle; Printing telegraphs, which actually print on a slip of a paper, or other material, the signs or letters indicated; Alphabetical telegraphs, so called because they point to, or print the letters of the ordinary alphabet; Magnetic telegraphs, which derive their name from the motive power, which is a magnetic and not a voltaic battery; Submarine telegraphs, intended to convey signs by means of wires or cables laid at the bottom of the ocean bed, and so forth.

To this last species of telegraph we confine our attention in the present paper; and here we shall find the main interest to lie in the construction of the conducting wire, and its safe submersion in the bed of the ocean; for the difficulties attending the construction of a continuous wire of several miles in length, its perfect insulation, and safe submersion in the bed of the ocean, are so great, that every experiment of the kind is watched with the deepest anxiety by all concerned in its success. We shall not, therefore, stop to examine the source of electric power, or the indicating instruments at each end of the system, it will suffice for the occasion to observe that they are the same as in all other telegraphs in use, and are not likely to affect the success of any undertaking where the continuity and insulation of the conducting wire are perfect. The batteries may be either voltaic or magnetic, and the indicating instruments may resemble any of those ordinarily seen in the room of a telegraph office, but the conducting wire must be specially adapted to the circumstances of each particular case.

Among the circumstances which affect the well-being of a conducting wire in the *submarine* telegraph, the most important are the nature of the *ocean bed*, the action of the *sea-water*, and the attacks of *marine animals*.

First, as to the ocean bed. If the sea-bottom be very uneven, rising here into mountains, and falling there into valleys, a much greater length of wire will be required to reach a given distance than would be necessary if it could be laid down in an even line. So great was the difference in the first cable laid across the Straits of Dover, that when the whole of it was payed out, the shore was not reached, and an additional portion had to be made before a landing could be effected. In the present Atlantic cable 630 miles have been allowed to make up any deficiency which might arise from the same cause, and this will explain what appears to have puzzled some people when they read the account of the submersion of the cable during the past month. The telegrams ran after

this fashion, I quote literally:—"Three hundred and fifty nautical miles of cable were payed out at 12·50 p.m. to-day, and 350 miles were run at 4·50 p.m." Again: "Five hundred nautical miles of cable were payed out at 10·50 a.m. to-day. The distance run was 460 miles." In reading these two telegrams, it will be observed that, in the first case, 350 miles of cable were payed out soon after mid-day, but that it took *four hours* longer before the ship had made the same distance from land. In the second case, we see that at one and the same instant of time, the length of cable payed out was forty miles greater than the distance the ship had traversed—the difference being due to the irregularities of the ocean bed, together with some other deflections from a right line, caused by submarine currents, and the divergence of the ship itself from a perfectly straight course. Moreover, there may be chasms in the sea-bottom not detected by the sounding line, across which the cable would be stretched, in which case the tension of the wires would be such as to render it amenable to many untoward influences.

Supposing, however, that the bed of the ocean is tolerably even, it may yet lie so far below the level of the surface as to offer very serious obstacles to the successful laying down of a telegraph cable. The new Atlantic cable was constructed with special reference to this source of danger. The deepest water to be encountered in its course between Valentia Island and Newfoundland was 2424 fathoms, or little less than $2\frac{1}{2}$ miles. Now, the weight of the cable in water is about 14 cwt. per mile. Hence,

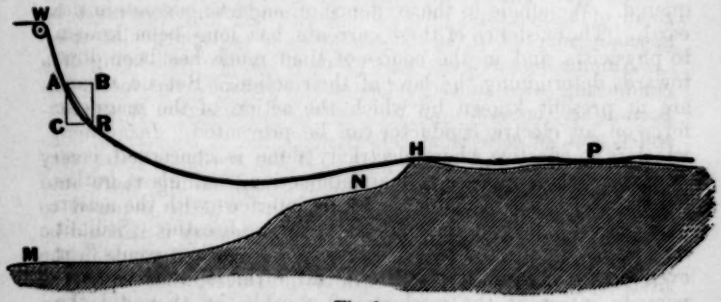


Fig. 1.

if the cable were delivered freely, and fell nearly perpendicular from the stern of the vessel, there would never be a strain of more than about two tons upon the cable during immersion; while the breaking strain which it is calculated to bear is $7\frac{1}{4}$ tons. But it is not likely that the cable would be paid out so easily

throughout a course of nearly 2000 miles, and irregularities in the sea bottom, such as represented in Fig. 1—though here violently exaggerated—would cause the cable to hang in the form of a curve of greater or less length, according to the freedom with which it was payed out, and the nature of the ground over which it had to pass. The strain upon the cable then would not be the simple weight of the cable itself, but would be compounded of two forces. Let M N P be a section of the sea bottom, H R A the cable, passing over the wheel W at the stern of the ship. Then if A C represent the vertical strain upon the point A, which would vary according to the depth of water, and A B the horizontal strain, varying with the distance of the point of suspension H, the resultant force tending to break the cable would be represented by the line A R, and would of course be greater with every increase of the horizontal strain A B, or of the vertical strain A C; and would invariably be greater than the mere weight due to the perpendicular depth of the cable, which in the diagram is indicated by the line A C. Practically, therefore, it is desirable to diminish the lateral strain, especially in deep water, as far as possible, so as to secure a perfect settlement in the sea bed at as small a distance astern as is practicable; otherwise the strain may be so great as to exceed its "breaking strain."

While speaking of the nature of the ocean bed as affecting the operation of telegraphic wires, it is necessary to notice the action of another force of a most subtle character, one which perhaps may present difficulties when all others have been conquered. We allude to the existence of *magnetic currents* in the earth. The existence of these currents has long been known to physicists, and in the course of time much has been done towards determining the laws of their action. But no means are at present known by which the action of the magnetic force on an electric conductor can be prevented. *Insulation*, which is so effective where electricity alone is concerned, is so powerless when opposed to magnetic action, that glass, gutta-percha, and other insulators scarcely interfere with the action of a powerful magnet more than the air we breathe. Still, it may be fairly expected that the action of "earth-currents," or even of "magnetic storms," will do little more than temporarily interrupt the working of a cable, as they did the working of the terrestrial lines lying between Croydon and the Royal Observatory, Greenwich, on the 3rd, 4th, and 5th of the present month, on which occasion a magnetic storm was experienced more violent than any that had ever been previously recorded.

Passing now from the consideration of the ocean-bed to that of the action of sea-water upon a submerged cable, we

see at once that it will be of two kinds—mechanical and chemical. Both of these have to be specially guarded against. The *mechanical* action arises chiefly from the movement of submarine currents, the direction and extent of which are very imperfectly known to hydrographers. The superficial marine currents, such as the Gulf Stream and others, have been thoroughly explored; and it may be safely inferred, from hydrostatic principles, that where a superficial current exists, there must be, in general, a submarine current somewhere answering to it; but beyond this, little can be stated positively about them. Wherever they do exist in any force, their effect on the bed of the ocean must be very considerable; and if a telegraphic cable should cross the course of such a current, it would be liable to wear and tear, from the attrition of the cable upon the solid rocks, and from the action of the water, which would be often greatly aggravated by its holding in suspension fragments of rocks and mineral débris. As to the *chemical* action of sea-water, its activity is well known; and the iron wires which surround the copper in a cable would stand no chance at all, unless protected by "galvanizing"—that is, covering them with a coating of zinc; or, still further, by "serving" them with tarred hemp.

One might suppose that a cable so protected would be tolerably safe from depredations of every kind. But in warm latitudes, where animal life abounds in the ocean, cables have been rendered quite useless, in consequence of the attacks of these unexpected foes. Nibbling at the hempen covering, they have laid bare the wires, which in turn soon yielded to the corroding influences of the sea-water, and the utter destruction of the cable was the result. In other instances, corals and barnacles have attached themselves to the cable in positions where it has been stretched from rock to rock, when, by their united weight, they caused a strain which the wires could not resist. In more northerly latitudes, there is less to be feared from this cause; nevertheless, as any one who has spent a day at the sea-side has had an opportunity of noticing, there are many molluscs—the *Pholas* and *Limpet* to wit—which possess an extraordinary power of abrading and boring the hardest substances to which they attach themselves; and one never knows how far he is safe from the attacks of such minute and insidious aggressors.

The Atlantic telegraph cable, the object of so much interest at the beginning of the past month, was constructed with due regard to all the difficulties heretofore mentioned, and the manner in which the projectors proposed to meet them can scarcely fail to prove interesting.

In Fig. 2 we have a chart of that portion of the Atlantic

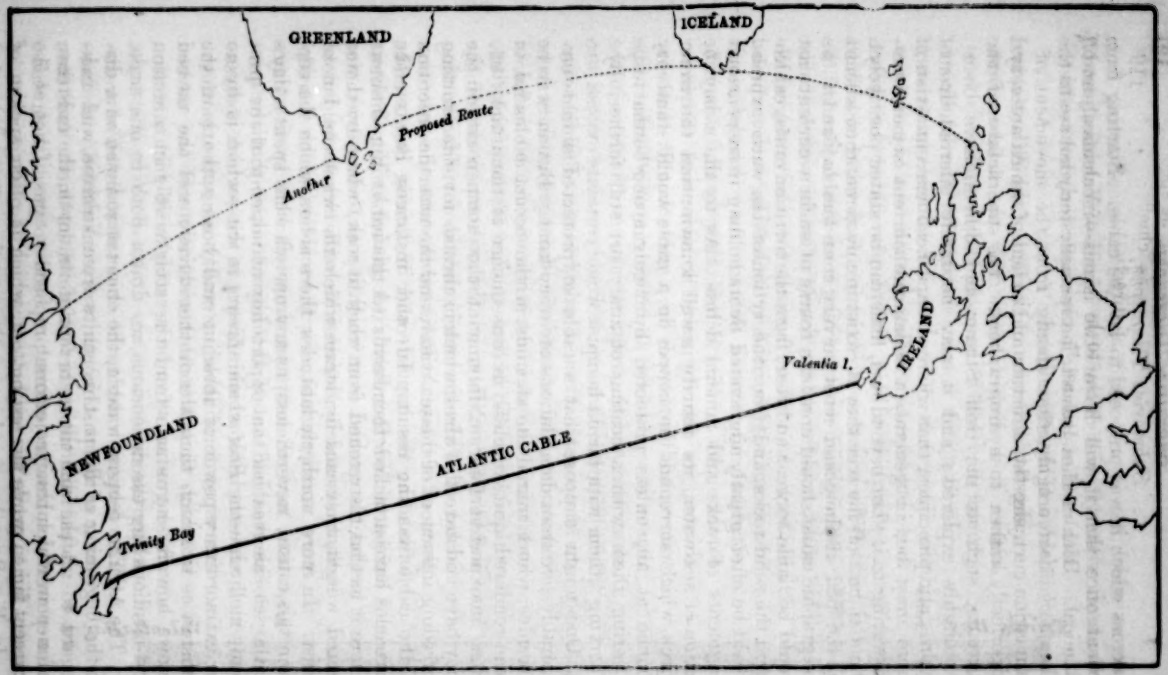

GREENLAND
ICELAND
Proposed Route
Another
IRELAND
Valentia I.
NEWFOUNDLAND
ATLANTIC CABLE
Trinity Bay

Fig. 2.

across which it was proposed to lay the cable. Starting from the most westerly point of the little island of Valentia, just off the coast of Ireland, it took a westerly course to the island of Newfoundland.

Fig. 3.

Fig. 3 is a section of the bed of the Atlantic, and shows in a certain rough way the nature of the ground over which the cable had to pass.

In fixing on a spot suitable for the landing of the shore ends of a cable, it becomes a question of some importance whether it shall be a *bay* or a *promontory*. If a bold, abrupt promontory be chosen there is a chance of obtaining deep water at a short distance from shore, while, from the nature of the coast, it is the most unlikely place for vessels to cast anchor. As a set-off against these advantages, the waves are apt to be very violent in such exposed situations, and much damage may thereby result to the cable. If, on the other hand, a bay be chosen, we thereby gain the advantage of quieter waters, and sometimes deep ones; but for that very reason it would form an inviting spot wherein to lie at anchor, and the frequent casting of anchors in the neighbourhood of a cable would certainly expose it to great danger. From a consideration of all these circumstances, the balance of advantages appears to be in favour of a quiet bay, when one can be found in which the traffic is not too great; and the little Foilhommerum Bay, on the western coast of the island of Valentia, was selected for the starting point of the late Atlantic cable, with the intention of landing the opposite end in Trinity Bay, on the coast of Newfoundland. A glance at Fig. 3 shows that the ground over which it was to be carried was characterized by depressions and elevations, but of very small amount; for the scale on which the vertical measurements are drawn is here twenty times as great as that of the horizontal, so that the precipitous bank which appears in the section is by no means so formidable in reality as appears in the drawing, while the other undulations of the sea bed are so gradual as to be scarcely visible in a section where the dimensions are drawn both to one scale. The deepest water to be encountered was at a distance of about 1150 miles from Valentia, and indicates, from the mere fact of its depth, the existence of a powerful submarine current in former ages, if not at the present time; while the sea bottom, which is often spoken of

as consisting of ooze, is known to be rocky and rough to an extent that would justify considerable fears for the continued integrity of any cable lying across it.

In order to appreciate the precautions taken with the last cable with a view to guard against a failure similar to that of 1858, a comparison of the two cables may here be made. A longitudinal and sectional view of each is given in Figs. 4 and 5. A glance at these diagrams, which are drawn of the same

OLD ATLANTIC CABLE, 1858.

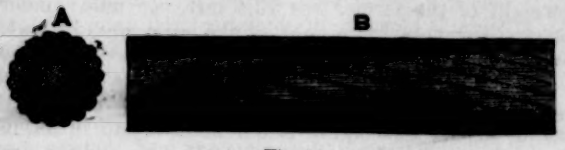


Fig. 4.

NEW ATLANTIC CABLE, 1865.

Fig. 5.

diameter as the cables themselves, will at once inform the reader of their respective sizes. The diagram A in each figure is the sectional view, and B a longitudinal. The conductor in each consists of seven wires (six laid round one), but in the cable of 1858 this copper strand weighed 107 lbs. per mile, while that of 1865 weighed 300 lbs., which was embedded for the sake of solidity, and not with a view of insulating the wires from each other, in a matrix of Chatterton's compound. These conducting wires were insulated in the former case by gutta percha, laid on in three coverings, and weighing 261 lbs. per mile; in the latter by four coverings laid on alternately with thin layers of Chatterton's compound, making a weight of 400 lbs. per mile, and bringing up the core to a diameter of nearly half (·464) an inch. For the protection of this essential part the cable of 1858 was surrounded by eighteen strands of iron wire, each strand consisting of seven wires (six round one), laid spirally round the core, the latter having been previously

padded with a serving of hemp saturated with a tar mixture. In the cable of 1865 the core was protected by ten solid wires, nearly $\frac{1}{10}$th of an inch diameter, drawn from Webster and Horsfall's homogeneous iron, each wire being separately surrounded with five strands of Manilla yarn, saturated with a preservative compound, and the whole laid spirally round the core, which latter was padded with ordinary hemp, also saturated with preservative mixture.

The weight of the 1858 cable *in air* was 20 cwt. per mile; that of the 1865 cable was 35 cwt. 3 qrs. per mile. *In water*, the weight of the former was 13·4 cwt. per mile; under the same circumstances the weight of the latter was 14 cwt. per mile. A comparison of these last figures shows that although the latter cable was so much stronger than the former, yet its weight in water was increased by a very small amount. The breaking strain—that is, the strain necessary to break it—in that was 3 tons 5 cwt., in this, 7 tons 15 cwt., and the deepest water to be encountered in each case was 2400 fathoms, or thereabout. The length of cable shipped in 1858 was 2174 miles; in 1865, 2300 miles; and as the total distance from Valentia to Newfoundland was 1670 miles, there were 630 miles available to meet the irregularities encountered in its course.

In addition to the protection above spoken of, the shore ends of the new cable were further protected by iron wires of still larger bulk; so that the entire diameter of the cable with its protective covering was about $2\frac{1}{2}$ inches. This diameter was maintained for the distance of 5 miles, when the protecting wires were diminished in bulk, which bulk they maintained, however, through another five miles; and so on, diminishing every five miles, till, at a distance of about twenty-five miles, the dimensions of the main cable, as above described, were arrived at.

The following is a condensed history of the process of its submersion:—

July 22.—At Foilhommerum Bay, "Caroline" commenced laying the shore end. At 11·30 p.m. completed laying the shore end.

July 23, 4.25 p.m.—Shore-end spliced to main cable on board the "Caroline." At 4·50 p.m. the "Great Eastern" commenced paying out.

July 25.—"Great Eastern" telegraphs that a small fault had been discovered and cut out. Now paying out again. Signals perfect. Weather very fine.

July 26, 6·50 a.m.—Cable paid out 150 miles. 9·50 a.m.—Distance run 150 miles.

July 27, 5·50 a.m.—Cable paid out 300 miles. 9·50 a.m.—Distance run 300 miles.

July 28, 9·50 a.m.—450 miles run. 10·50 a.m.—Cable paid out 500 miles.

July 29, 6·50 a.m.—Cable paid out 650 miles. 8·50 a.m.—Distance run 600 miles. *Evening.*—Accident to cable. Cause unknown. Total loss of insulation; no information from or communication with ship.

July 30, *morning.*—All going on well. Fault removed. 1·50 a.m., insulation perfect. 4·20 p.m., cable paid out 750 miles. Distance run 650 miles. Continuity and insulation perfect. All going on well.

July 31, 7·50 a.m.—Distance run 750 miles. 1·50 p.m.—Cable paid 900 miles.

Aug. 1, 9·50 a.m.—Distance run 900 miles. 10·50 a.m.—Cable paid out 1050 miles.

Aug. 2, 6·50 a.m.—Distance run 1050 miles. 7·50 a.m.—Cable paid out 1200 miles. 8 p.m.—Signals from ship unintelligible at noon to-day. No communication with or information received from ship since. Cause unknown.

Aug. 3, 11·30 a.m.—No information received from ship. Cause unknown. No communication with ship.

* * * * *

From this date up to the morning of the 17th of August no intelligence of any kind was received from the ship. On the morning of that day, the "Great Eastern" was sighted off Crookhaven, and a few hours afterward was telling her story to thousands of waiting ears. But as the story involves frequent mention of "testing," "grappling," and "hauling," terms having a much more refined application than is commonly assigned them, we will wait in hope of another opportunity of bringing a full description of these processes before our readers.

COMETS.

AN ACCOUNT OF ALL THE COMETS WHOSE ORBITS HAVE NOT BEEN CALCULATED.

BY G. F. CHAMBERS.

(*Continued from Page* 374, *Vol.* vi.)

1338. On April 15, a comet was discovered. The sun being then in Taurus the comet was at the beginning of Gemini. Its movement was from W. to E. with a declination increasing N. It followed the sun and set about midnight. On April 17, it was in 24 or 25° of Gemini. From a note by Friar Giles, it appears that its latitude was then 17° or 18° N. It remained in sight a fortnight or more.—(*Chronicon Rotomagense.*)

1340. On March 24, a comet was discovered, whose R. A. was 12° greater than π Scorpii. "When first seen it was in the latter part of Libra; then it retrograded at the rate of 5° a day, till it came to Leo, when it disappeared." It was visible thirty-two days.—(Gregor. *Hist. Byzant.* xi. 7, 5; De Mailla, ix. 576; Gaubil.)

1345. At the end of July, a comet appeared near the head of Ursa Major. It advanced, day by day, to the Zodiac, and when it reached the latter part of the sign Leo, where the sun was, it disappeared.—(Gregor. xv. 5, 6.)

1347. In the last year of the reign of Louis of Bavaria, a comet appeared for two months. In Italy it was only seen during fifteen days in August, in 16° of Taurus, in the head of Medusa.—(*Chronicon Nuremburgense.*)

1356. On September 21, a comet was seen in 17° 10′ of the constellation *Tchang* (ϕ, γ, λ, υ, κ Hydræ), it remained visible till November 4.—(Gaubil.) When discovered it was as bright as Regulus (α Leonis).—(Biot.)

1360. A comet was seen in the E. for a few days, from March 25.—(*Chronicon Zwetlensis*, De Mailla, ix. 633.)

1362. [ii.] On June 29, a comet was seen in the circumpolar regions with an R.A. 2° 90′ (qy.) greater than β Capricorni.—(Biot says 9·9°.) It went to the S.W., and on August 2 had disappeared, having lasted six weeks. Its tail was one foot (or degree) long.—(Gaubil; Pingré, i. 440.) De Mailla says that the comet appeared near α and β Aquarii, and that its tail was more than a *hundred* feet long.—(*Hist. Gén.* ix. 640.) This account is altogether irreconcilable with Gaubil's. Can there have been *three* comets this year, or does not De Mailla rather refer to the first comet, whose orbit has been calculated, and therefore appears elsewhere?

1363. On March 15, a comet appeared in the E. for a month.—(Biot.)

1368. In February, March, April, a comet appeared in the evening, in the W. or N.W., to the N. of the Pleiades.—(Couplet; Walsingham, *Historia Anglica.*) On February 7, a comet was seen between the divisions of the Pleiades and Hyades. On April 7, a comet was seen in the N.W. between τ, κ. ρ, and a, γ, η Persei. The tail was 8° long, and pointed towards θ Ursæ Majoris. It ultimately disappeared to the N. of α and β Aurigæ.—(Biot.)

1371. On January 15, a very great comet was seen in the N. Its tail was directed towards the S.—(Bonincontrius, *Annales.*)

1373. In April, May, three comets entered the circle of perpetual apparition.—(Biot.)

1376. On June 22, a great comet appeared in ι, θ, η Ceti; it traversed δ, ϵ, μ, ν Piscium, ν Persei, entered the circle of perpetual apparition, swept θ, υ, ϕ Ursæ Majoris, and directing itself towards δ, ϵ, π, ρ Draconis, entered the sidereal division of ν^3 or 39 Hydræ. It disappeared August 8.—(Biot; Gaubil.)

1380. On November 10, a comet appeared.—(Cygnæus, *Chronicon Citizense.*)

1382. [i.] On March 30, a comet appeared.—(Bothonis, *Chron. Brunswicensis.*)

1382. [ii.] On August 19, a comet appeared in that part of the heavens where the sun sets in June. It lasted for fifteen days, and was seen two hours before sunrise, though these two latter statements may be open to doubt.—(*Annales Vicentini.*)

1382. [iii.] In December, a comet appeared in the W. for more than a fortnight.—(Walsingham, *Historia Anglica.*)

1388. On March 29, a star came from the division γ Pegasi.—(Biot.)

1391. In May, a small comet appeared near the stars of Ursa Major. Its tail was not very bright.—(*Annales Forolivienses.*) Biot says that two comets appeared on the twenty-third of this month. One entered the circle of perpetual apparition, between a and ι Draconis, and passed to the S. of θ Draconis, and the other passed by the N. of Camelopardus, and swept the pole-star.

1399. In November, a star of extraordinary brilliancy was seen; its tail was turned towards the W. It lasted only a week.—(Mezerai *Histoire de France.*)

THE CATTLE PLAGUE AND SCIENTIFIC INVESTIGATION.

THE excitement caused throughout the country by the prevalence of the typhoid disorder popularly called the "cattle plague," has not induced a state of mind very favourable for accurate scientific investigation; and yet it is impossible to read the reports of speeches delivered in various districts without perceiving the urgent need of a rigid inquiry. In the absence of accurately collected facts and cautious reasoning we are likely to be afflicted with an epidemic terror, capable of doing more mischief than the disorder that has given rise to it. It is especially the fashion of the hour to assail the foreign cattle trade, and to set up the most violent theories of contagion, infection, etc. Those who are familiar with social history will see in these incidents only a repetition of what has often occurred before, and what has been demonstrated to be unreasonable, whenever it has been adequately investigated. No one doubts that a very minute quantity of matter in particular conditions is capable of setting up disease in appropriate subjects; and questions of contagion, infection, etc., really resolve themselves into inquiries concerning the action of infinitesimal doses of poison conveyed by divers methods into the organization of living beings. The surgeon puts a small quantity of his vaccine matter into the arm of an infant, and he thereby sets up a morbid action. The mad dog inserts a probably smaller quantity of a more virulent poison into the body of his victim, and fatal results often ensue. A pestilent marsh gives off in its vapours and exhalations a minute quantity of some matter that has escaped the chemist's investigation, and which may exist in quantities too minute for his analysis. This morbific matter is breathed for a short time by one passing through the swamp, and he carries away with him a supply of some sort of ague that may last for the remainder of his days. In such cases, and in others that might be easily imagined, we have a transfer of a more or less infinitesimal portion of matter in a particular state, from the situation in which it originated, to some other situation in which it excites chemical or other actions hostile to health and life.

It concerns not our present inquiry whether the poisonous matter be itself organic, as in the case of fungoid or other microscopic vegetation, or whether it be merely a complex compound undergoing changes by which it is able to excite analogous changes in the complex compounds of which the soft and fluid parts of living creatures are composed.

The ultra-contagionist or infectionist goes to the greatest lengths of his imagination in ascribing deadly qualities to the most minute and diluted quantities of the sorts of poison which are under consideration. His opponent, without denying that exceedingly minute quantities of certain substances can excite disease, contends that, with due precautions, actions of contagion, infection, etc., may in many cases be so minimized as to be practically harmless, while in another class of instances, in which the poison appears to be diffused over large areas by atmospheric currents, he sees the futility of attempting to exclude is by measures of quarantine.

We shall select an instance of infection run mad from the proceedings of the College of Physicians in 1831, when the Asiatic cholera frighted these isles from their propriety, and when no less a person than Sir Henry Halford presided over the august body that took the lead in talking nonsense and exaggerating alarm. In opposition to the more mature opinion of the physicians of Bengal, the medical board over which Sir H. Halford presided declared that plans for keeping out cholera by quarantine had been found effectual. They then recommended the following truly insane measures:—

"To carry into effect the separation of the sick from the healthy, it would be very expedient that one or more houses should be kept in each town, or its neighbourhood, as places to which every case of the disease, as soon as detected, might be removed, provided the family of the afflicted person consent to such removal; and in case of refusal, a conspicuous mark SICK should be placed in front of the house to warn persons that it is in quarantine; and even when persons with the disease shall have been removed, and the house shall have been purified, the word CAUTION should be substituted, as denoting the suspicion of the disease; *and the inhabitants of such house should not be at liberty to move out or communicate with other persons until by authority of the local board the mark shall be removed.*"

The next paragraph of this singular medical document recommended that persons dying of cholera should be buried in a detached ground near the house in which they perished, and that "*all persons who may be employed in the removal of the sick from their own houses, as well as all who may attend upon cholera patients in the capacity of nurses, should live apart from the rest of the community.*" So violent was the mental disorder at this time afflicting the College of Physicians, that they did not stop at the absurdities we have cited, but advised "all articles of food, and other necessaries required by the family, should be placed in front of the house, and received by one of the inhabitants of the house after the person delivering them

shall have retired," and that convalescents, and all in communication with them, should be kept under surveillance for twenty days. Further than this, the local magistracy was invoked to stop intercourse with infected towns; and if the disease assumed the terrific form known on the Continent, the philosophical guardians of the public health declared, "*it may become necessary to draw troops, or a strong body of police, around infected places*, so as utterly to exclude the inhabitants *from all intercourse with the country.*"

We leave to medical science the task of deciding whether the learned body from whom this rubbish emanated was suffering from some form of *hysteria*, but in tracing the facts of the time it would appear that, from want of due sanitary precautions, their complaint was communicated to the "King in Council," who published their recommendations in form of an "Order." Happily their disorder did not become epidemic, and the people declined to be as foolish as their learned advisers wished. Very absurd things were, however, submitted to; and, amongst other ridiculous regulations, communication between London and Edinburgh was *prohibited by sea*, lest the cholera should travel in the same ship; but *permitted by land*, as the authorities had a notion that it would not take passage by the old mail coach!

It is obvious that an immense amount of poverty, misery, disease, and death would have been the result of carrying out all the insane recommendations of the College of Physicians of that day. Business would have been at a stand-still, wages and profits temporarily abolished, abject and unmanly terror would have seized possession of the land, and we should soon have realized the condition imagined by the poet, in which "darkness" might have been "the burier of the dead." If we endeavour to ascertain why a grave and learned body of fairly able men propounded so much perilous nonsense in the most solemn good faith, we shall first observe the tendency of terror to spread by what we may be permitted to call mental contagion. Secondly, we shall see the mischievous effect of an undue and unphilosophical reverence for authority. Extravagant doctrines of contagion and infection had come down to the medical schools from the middle ages, and only a few great thinkers, like the late Southwood Smith, ventured to doubt what it was considered sound orthodoxy to believe. There was, in the third place, a remarkable want of *verification*, a process which Mr. Lewes, in his *Life of Aristotle*, shows to have been neglected by the ancient world, and which the moderns too frequently fail to employ.

One of the noblest contributions to recent literature, Mr. Grote's *Plato and other Companions of Socrates*, is full of apt

illustrations of the value of negative inquiry. He shows most forcibly that investigation is not only useful for the discovery of truth, but also for the purpose of ascertaining the real bounds of knowledge, and of learning the precise force of reason that can be alleged in favour of any particular proposition that authority recommends.

If the College of Physicians, in 1831, had felt the logical and scientific necessity of negative inquiry and verification, they would not have so completely stultified themselves. They accepted upon authority doctrines which inquiry would have greatly modified, and they assumed propositions to be correct which were known to be incorrect by other persons better acquainted with the case.

We have only to read the daily papers to see that the frame of mind in which the College of Physicians proved a misguider of those who believed in them, is now more or less prevalent in many quarters, and were the doctrines and opinions of the ultra-cattle-contagionists acted upon, we might expect a great rise in the price of meat, as the result of a violent interference with trade.

We are far from contending that the Government should be inert in such a crisis, but certainly one of its primary duties is to collect and arrange facts so as to know what it is about. If every cow from foreign parts is to be treated as Sir H. Halford and his colleagues proposed to treat every individual who had intercourse with a cholera patient, the interference with the import trade of cattle will be vexatious and mischievous in a high degree. If every cow suspected of the disease is to be at once killed, a needless destruction of stock must take place, and if farmers and others are taught to believe in the extremest form of the contagion and infection theory, it is difficult to see how they can shape their conduct by rational rules.

It is not likely that disorders affecting cattle differ materially from those which affect human beings, and though the records of epidemics point most clearly to measures of caution and prudence, they do not justify the sort of alarm of contagion which runs through most of the speeches we now read.

The Board of Health Reports on Quarantine abound in illustrations of the fallacy of particular arguments, set up at various times and in various places, concerning the importation of disease and the force of contagion. We have seen how strong was the belief in the professional mind of the contagious character of cholera, and yet that has passed away under the influence of a more accurate observation of fact. In like manner it was imagined that quarantine was necessary and

successful in stopping the spread of yellow fever, and yet the evidence published by the Board of Health in the second of the Reports* to which we have alluded, tells precisely in the opposite way. "During the late epidemic of British Guiana," says Dr. Blair, "the yellow fever cases in their worst forms were never separated from other patients in our hospital wards. Such a thing was not deemed necessary, and was never thought of . . . . Our hospital nurses never got infected, although in the closest connection with the sick, and often smeared with their ejections . . . . The resident surgeons, dispensers, and stewards were all susceptible subjects, and with one exception escaped without attack."

It by no means follows that because this sort of evidence might be multiplied to any extent with reference to cholera, yellow fever, and certain other disorders, a similar investigation would terminate in the same way if the cattle plague were the subject of scientific inquiry, and as our purpose is to enforce a scientific method of investigation, we do not wish such information to go for more than it is worth. The cattle plague *may* possess powers of contagion greater than any known disorder, but plenty of other disorders have been spoken of in the same terms, and we do not recollect a single case in which the alarm of contagion has not been diminished when an epidemic has been studied in a scientific way.

This tendency of inquiry to reduce fear is exemplified in the course of opinion on the cattle plague. At first the ultra-contagionists seemed to have it all their own way, though some cautious authorities like Professor Varnell immediately pointed out the probability of their mistake. At the time we write Professor Dick of Edinburgh has expressed similar views, and several letters from agriculturists tend to diminish alarm. Important practical opinions on the question are also given by a cow and a calf at the Royal Veterinary College, who for a month past have not availed themselves of their alleged opportunities of catching the disease, which has carried off seven or eight of their companions in the very next sheds.

The want of air, light, and ventilation in many, perhaps we might say, most cattle sheds and dairies, supplies conditions remarkably favourable to the generation and spread of disease, and the wonder is that loss from such causes is not greater than we are accustomed to, and to these constant sources of danger we may add the prevalence of hot, moist weather, which has exerted a depressing influence upon men and animals.

The materials for forming opinion exist in unhappy abundance with reference to the cattle plague; but the public are not in possession of an adequate number of verified cases to

* 1852.

be able to judge of the real extent of the danger and the best mode of averting it. It would be well if the Government "improved" this occasion by making better preparations for the future. There should be a constant collection and classification of what Bentham called "pre-appointed evidence," that is, evidence ready to assist inquiries likely to be made and worth making. The sifting and verification of evidence of this class is a difficult task. The medical man must be relied upon for the detection and naming of the disease, but as soon as he begins to form a theory of the mode of its introduction or propagation, he cannot lay claim to any special authority, as there is nothing in his education or habits that peculiarly fits him for rigid logical inquiry. The highest class of scientific men—medical included—are able and cautious reasoners—more given to wholesome doubts and processes of verification than ordinary persons. Such men are necessarily rare; but when the occasion is sufficiently important, it is in the power of the State to secure their aid.

If the cattle disease lasts till Parliament assembles, proposals for investing the Government with fresh powers will be sure to be made. It is natural that in a matter of so much moment and difficulty the intervention of the State should be invoked; but it will be incumbent upon the Legislature to sift the evidence that may be adduced in the most cautious way. By collecting accurate information, and spreading it, the Government may be sure to do good; but if it relies too much upon measures differing materially from those of general sanitary precaution, it may do much harm. Mr. Arthur Helps, the Secretary to the Privy Council, states that "it does not appear that in countries where the Government possesses the amplest powers for dealing with cases of this kind, and where they have exercised those powers with great vigour, any signal success has attended their measures." This is a very important statement, and the evidence upon which it is made should be most carefully weighed. That it is correct, we think most probable; but if so, much of the ground for State intervention is cut away.

The most safe course for the Government is to be very moderate in restrictive enactments, and to rely chiefly upon its power of usefully influencing opinion, by collecting the best information, and subjecting it to the scrutiny of the ablest men.

We have now a well-educated body of veterinary surgeons, upon whom considerable reliance may be placed; but, to utilize their labours, they must be treated in a scientific manner, and great pains taken to discriminate between their *bonâ fide* observations of *fact* and the habit they possess, in common with other mortals, of mixing hypothesis with the record of

phenomena. A rigid observation and description of fact is one of the most difficult arts for a man to acquire, and few are the minds that keep a due balance of their powers when an epidemic excitement tends to give undue force to wonder and imagination.

CELESTIAL PHOTOGRAPHY.—ENGELMANN ON DOUBLE STARS.—CRIMSON STAR.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

In a recent number of the Intellectual Observer an account was given of Dr. Draper's Great Reflector with a silvered glass speculum 15½ inches in diameter, intended chiefly for the purpose of celestial photography. We now propose to give some details as to the mode of its application.

The first photographic picture of the Moon appears to have been taken by his father in the year 1840, when a Daguerreotype image was obtained by a 20-minutes' exposure, Daguerre himself having failed in a similar attempt. This experiment was made by means of a heliostat, or apparatus for reflecting the incident rays always in one direction, notwithstanding the motion of the body whence they flow. Dr. Draper, jun., has preferred an arrangement in which, the telescope remaining fixed, and the lunar image being allowed to pursue its own course, the collodion plate is caused to follow its path accurately by means of an appropriate moving power. Mr. De la Rue first suggested this ingenious mode of counteracting the earth's diurnal motion, and it has been carried into effect by the Earl of Rosse; but the mechanism employed by Dr. Draper was devised independently by himself and his brother. An attempt to move the slide carrying the collodion plate by means of screws turned by hand failed from the communicated tremors. A "sand-clock" which was substituted as prime mover, and which caused the frame to slide along two rods, answered much better, but an ingenious contrivance by which rolling was substituted for sliding friction was a still greater improvement, and admitted of the image being followed steadily for nearly four minutes, though fifty seconds were all that was ever found necessary. Two cross lines traced on ground glass are used as a preliminary guide in order to fix the direction of the apparatus parallel to that of the moon's motion, and when a lunar crater stands steadily on their intersection for twice or thrice the period required for exposure, the adjustment is

complete. Excellent photographs were taken by means of a slide thus supported, and driven by the "sand-clock," which consisted of a weight supported by a column of sand allowed to escape through an orifice whose dimensions were variable at pleasure to suit the required rate: and this arrangement was found superior to mercury-clocks and air-clocks, which had been tried in great variety. In fact, Dr. Draper expresses his belief that no prime mover is more suitable than a sand-clock for purposes where steady motion and a large amount of power are demanded. "The precision," he says, "with which such a sand-clock goes, may be appreciated when it is stated that under a power of 300 a lunar crater can be kept bisected for many times the period required to photograph it." Some precautions are however requisite, as might be expected, to secure accuracy of rate. The tube containing the sand should be "free from dents, of uniform diameter, and very smooth or polished inside. Water must not be permitted to find access to the sand, and hygrometric varieties of that substance should be avoided, or their salts washed out. The sand should be burned to destroy organic matter, and so sifted as to retain grains nearly equal in size. The weight, which may be of lead, must be turned so as to go easily down the tube, and must be covered with writing-paper or some other hard and smooth material, to avoid the proneness to adhesion of sand." He found, however, that these columns of sand were frequently liable to minute vibrations, which caused want of sharpness in the enlarged photograph, and an ingenious experiment was tried to obviate these, by substituting metallic for natural sand. The former may be prepared by melting lead with a little antimony, and shaking it while cooling in a box containing some plumbago, the effect of this being to solidify it in the form of a fine powder, about five times as heavy as sand, which only requires sifting to secure uniformity of size: when allowed to escape through a small tube, its flow is "entirely different from that of sand, looking as if a wire or solid rod were descending, and not an aggregation of particles." It would probably have answered better than sand, but the experiment was pushed no further, as a trial of a water-clock or clepsydra proved perfectly successful. This consists of a vertical cylinder with a water-tight piston, which carries at its top a 5lb. weight to move the sliding plate-holder; the lower end of the cylinder being terminated by a stop-cock, to regulate the escape of the water. There is also another stop-cock in a pipe proceeding from the lower part of the cylinder, through which, independently of the first stop-cock, when the piston is raised, the cylinder fills itself with water from a vessel underneath. This might of course be accomplished by a single stop-cock, but the object

of the second is to allow the first to remain undisturbed when its position gives an accurate rate, and the cylinder has become empty.

The great impediment to the production of uniform movement by such an apparatus is, of course, that as the amount of superincumbent pressure determines the rapidity of the escape of the water, and the consequent descent of the weight, this force is continually decreasing with the diminishing quantity of water in the cylinder. In Dr. Draper's clepsydra, this defect is remedied in the following manner. The plug of the principal stop-cock is not perforated by a round hole as usual, but by a slit, which reduces or augments the flow of water through it in a more uniform ratio. To the handle of the stop-cock is attached a strong rod in a vertical direction, reaching up the outside of the cylinder, and pressed by a spring against an excentric attached to the side of the cylinder, so that the turning round of this excentric regulates the movement of the stop-cock with great precision and delicacy, and the rating requires only a few moments. The position of the rod is shown by a divided arc. "Although it may be objected," Dr. Draper says, "that this contrivance seems to be very troublesome to use, yet that is not the case in practice; even if it were, it so far surpasses any prime mover that I have seen, where the utmost accuracy is needed, that it would be well worth employing."

It seems very probable that an arrangement similar in principle to either the sand-clock or the clepsydra might be employed to supply a cheap and convenient driving power for equatorially-mounted telescopes. Those who have been habitually subject to the annoyance of the rapid motion of an object through the field of a deep eye-piece, will readily appreciate the comfort and pleasure of using a driving apparatus which, by causing the telescope to follow the apparent motion of the heavens, keeps the object immovable in the centre of the field; and contrivances to effect this object, which is especially desirable for micrometric purposes, have been in use for a considerable time. There is more difficulty in accomplishing this point than might be apparent to a novice, from the circumstance that no reciprocating motion—such as that of a pendulum or balance-wheel—is admissible, because it causes the whole wheel-work to move by jerks, which would not only be perceptible but very annoying under the magnifying power of the eye-piece. Flies, therefore, such as are used in the striking train of a clock, or the mechanism of a musical box, have been adopted to act upon the resistance of the air; and these have been made capable of regulation by varying the position of the vanes at pleasure, or causing them to dip more

or less beneath the surface of oil or mercury. But these contrivances involve an expensive train of wheel-work, and it seems likely that one of Dr. Draper's prime movers would be found to answer with a much more simple arrangement; and it is on this account that they have been here described with so much detail, since they appear well worthy of the attention of the possessors of equatorial instruments.

In solar photography, the very short exposure required is secured, as on this side of the Atlantic, by a movable shutter, drawn by an india-rubber spring; this acts with such rapidity, that "the wavy appearance produced by atmospheric disturbance is not unfrequently observed sharply defined in the photograph, though these aerial motions are so rapid that they can scarcely be counted." To avoid this very short exposure, many experiments were made with an unsilvered mirror, reflecting, according to Bouguer, only 2½ per cent. of incident light; but the plan had to be abandoned, from the change of figure and focal length immediately resulting from exposure to the sun. It was found that a glass mirror, though only resting on a few points, can be raised to 120° Fahr. by putting it in the sunshine on a hot day. An unsilvered "flat," or plane mirror, was found to answer better. But the ingenious inventor considers that the "best means of acquiring fine results with solar photography would be to use the telescope as a Cassegrainian, and produce an image so much enlarged, that the exposure would not have to be conducted with such rapidity."

Dr. Draper found that the pinholes, coarseness of granulation in the reduced silver, liability to stains and markings, and spots produced by dust, which assume an offensive importance in enlarging the portrait, were all avoided by washing off the free nitrate of silver from the sensitive plate before exposing it to the light, and again submitting it to the action of water, and dipping it back into the nitrate bath before developing: the quantity of nitrate of silver, however, necessary to development when pyrogallic acid is used, he says, is better procured by mixing it, as usual, with the acid. His nitrate bath contains 40 grains to the ounce, and is acidified till it reddens litmus paper. Focussing takes place on the sensitive collodion itself, the actinic rays being cut off by a yellow glass just in front of it. A pasteboard screen is then placed in front of the telescope, and the yellow glass taken out; and after a lapse of twenty seconds (to obviate, presumably, any accidental tremors), the screen is removed for the operation. He developes with protosulphate of iron 20 grains, acetic acid 1 drachm to the ounce; and intensifies, if necessary, with pyrogallic and citric acid each ¼ grain, nitrate of silver

$\frac{1}{10}$ grain, water 1 drachm (this part of the process is never employed by Mr. De la Rue). Protochloride of palladium, he found, would increase the intensity of a negative sixteen times without any injury to the image, or the production of markings, and is only kept out of general use, he says, by the scarcity of the metal.

The shortest exposure was one-third of a second, the moon being twenty-one days old, but the sky singularly clear. The full moon would, under such circumstances, have required a much shorter exposure, the focal image being exceedingly brilliant. Occasionally, however, a reverse condition of the sky obtains for a month or six weeks, at least in America, when the pale-yellow moon emits non-actinic rays. This, which occurs in very dry weather, Dr. Draper is disposed to refer to dust in a state of minute division. In such a condition of air, the full moon depicted itself with only moderate intensity in twenty seconds; that is to say, forty times as long as usual.

The enlargement of the picture is effected by means of a concave mirror of 9 inches aperture, and 11½ inches focus (for parallel rays), worked to an elliptical figure of 8 feet distance between the conjugate foci, and intended to magnify seven times. At first the negative was illuminated by diffused daylight, and the entire aperture of the mirror used; but the whole image was not reproduced equally sharp in every part. Subsequently, by means of a heliostat, a solar beam 1½ inch in diameter was passed through the negative to the mirror, a little on one side of its vertex, and reflected back on the sensitive collodion plate at a distance; and it was found that, when so small a portion of the concavity was employed, an exact correspondence of the conjugate foci with theory was not demanded, and the mirror performed equally well, whether magnifying seven or twenty-five times. He has even succeeded with a photograph of the moon 50 inches in diameter, which has, as might be expected, a very imposing effect.

Dr. Draper adds some remarks on microscopic photography, in which the employment of a cell of ammonio-sulphate of copper proved very successful. This deep blue liquid was found by his father to have the property of transmitting only the more refrangible rays, with the advantage of a much larger beam of illuminating light without burning delicate objects, and also of much higher powers; and thus in 1856 they obtained excellently defined photographs of frog's blood-discs, Navicula angulata, and several similar objects, under a power of 700 diameters.

When our readers find that on some nights as many as seventeen lunar negatives were taken, most of which were

worthy of preservation, and that not less than 1500 were made in 1862 and 1863, they will form some idea of the extraordinary amount of perseverance which has been brought to bear by Dr. Draper upon this interesting object, as well as of the uncommon fertility of invention and resource which are apparent throughout his very striking and valuable memoir.

ENGELMANN ON DOUBLE STARS.

During the course of last year Dr. R. Engelmann, the observer at Leipzig, completed his measurements of 48 double stars with the 12 feet equatoreal of 8 inches aperture (Paris measure), which Steinheil, of Munich, has recently erected in that observatory. It may be interesting to our astronomical readers to be made acquainted with his results, and those of other observers cited by him, so far as they relate to the objects already described in our Double Star List, of which we shall adopt the order and numbering.

1. ζ *Ursæ Majoris.* The components of this fine pair are still relatively stationary.

4. *a Geminorum.* 5″·526. 242°·86 (1864·16).—Dembowski gives 5″·381. 241°·66 (1863·03).—Secchi, 5″·368. 245°·13 (1855·82).—The change of angle is very apparent, and in a few years we may hope for a more satisfactory determination of its period.

5. ζ *Cancri.* Engelmann could not divide A and B (the close pair), and speaks doubtfully even of the direction of the elongation. For $\frac{A + B}{2}$ and C (that is, for the distance and angle between C and the centre of the compound mass of A and B), he gives 5″·49. 141°·3 (1864·31).—Demb., 5″·477. 140°·56 (1863·05).—Secchi, 4″·929. 141°·2 (1855·19). The angle is evidently changing more than the distance. It seems rather singular that the large aperture of the Leipzig achromatic (8½ English inches) should have failed to deal with the close pair: but from some optical imperfection it evidently gives too large star-discs, 0″·7 to 1″ for 3 or 4 mag., so that it will only elongate γ^2 *Andromedæ*, which Dembowski could frequently separate with an inch less of aperture. In this instance Steinheil's work must be pronounced inferior to that of Merz. My Clark, too, has obviously a great advantage in proportion to its size, as, with only 5½ inches, 450 *almost* divided ζ *Cancri*, when it must have been still closer, 1865·17. But the superior action of a really parabolic speculum on this class of objects was fully proved a little afterwards (1865·27), when with 8 inches of silvered glass, wrought by Mr. With to a focus of only 6 feet, I saw with a power of about 800 an

unmistakeable black division between the two minute discs of A and B, though, according to Mr. Dawes, their central distance was then only 0″·63. Steinheil has asserted, in explanation of this defect in separating power, that the magnitude of the spurious discs of stars depends not only upon the intensity of their light, but also upon the proportion of aperture to focal length, which is small in the Leipzig telescope. Airy, however, has shown that, from the undulatory theory of light, this magnitude must depend solely upon amount of aperture, without reference to focal length; and Dawes, speaking from an experience admitting of no appeal, affirms that practice is in accordance with theory.

8. *γ Virginis.* 4″·03. 348°·27 (1864·48). The latter measure is, perhaps, he observes, too large. He also states that both stars appear somewhat variable; and hence results the difference of his position-angle from those we formerly gave. These will be brought into harmony with it by adding 180°, which is equivalent to reversing the order of brightness; the more brilliant component being always chosen as the centre of measurement. Demb. has the same estimate. His data are 4″·085. 345°·9 (1863·33).

15. 51 *Librœ* (alias *ξ Scorpii*, entitled by Engelmann *ξ Librœ*). He failed in separating A and B, noting an elongation towards 15°, June 19; 350°, July 22. Demb., too, could only *wedge* it, but with measured angles of much greater consistency. This must be a fine test for the largest class of instruments, though unfortunately at rather a low elevation—10°·55′ S.D.—For $\frac{A + B}{2}$ and C, Engelmann gives 7″·41. 68°·95 (1864·48).—Demb., 7″·154. 70°·46 (1863·12).—Secchi, 7″·503. 70°·47 (1855·54).—Struve, 6″·75. 78°·6 (1825·48). There is evidently angular motion in this star.

20. *ξ Boötis.* 5″·32. 303°·4 (1864·46).—Demb., 5″·59. 303°·03 (1863·15).—Secchi, 6″·017. 310°·05 (1856·88). Hence its rapid motion is evident both in angle and distance.

22. *ζ Boötis.* 0″·87. 306° (1864·5).—Secchi, 0″·995. 305°·7 (1855·7).—Struve, 1″·189. 309°·17 (1830·47). Here we detect, at last, pretty certain evidence of motion in a double star, formerly considered stationary. By drawing up closer, while it gains the character of an unquestioned binary, it loses some value as a permanent test-object, for which purpose, however, it answers as yet admirably. My 5½-inch aperture divides it at present well with a power of 450, giving a dark interval equal to about 0·2 of either disc. Its gradual approach should be watched by all observers whose instruments can reach it, and measured by all whose apparatus can master it. It is not improbable that this *ζ*, and *ζ Cancri* already

described, may be following the example of a third ζ, that of *Hercules*, a wonderful pair, of very short, though not well ascertained period (Struve giving it but 14 years, Sm. 35); which having been measured by the latter at 1″·2 (1842·57), has of late years actually closed up to apparent unity. ζ *Boötis* is rendered additionally remarkable by Engelmann's confirmation of Struve's idea, that both stars are variable.

24. *a Herculis*. The stationary character of this fine object is confirmed.

25. δ *Herculis*. This also seems, notwithstanding previous conjectures, to be only optically connected.

26. δ *Serpentis*. 3″·313. 190°·73 (1864·42).—Demb., 3″·198. 192°·20 (1863·43).—Secchi, 3″·066. 195°·52 (1855·89). The suspected motion in this pair is now sufficiently evident.

27. κ *Herculis*. Stationary.

35. ζ *Coronæ*. 6″·195. 302°·8 (1864·48).—Secchi, 6″·213. 301°·71 (1856·49).—Struve, 6″.002. 300°·86 (1829·7). Hence Engelmann infers a slight, but pretty certain change of angle.

37. σ *Coronæ*. 3″·115. 190°·52 (1864·45).—Demb., 2″·759. 190°·06 (1863·09). The continued motion of this beautiful binary is evident, and it is to be hoped that we shall soon be in possession of data for computing a more satisfactory orbit.

38. η *Coronæ*. 1″·09. 28°·25 (1864·45).—Demb., 0″·81. 19°·04 (1863·03).—Secchi, 0″·535. 4°·5 (1859·48). The rapid movement of this most interesting pair is apparent, even from year to year, and its mutual divergence has brought it within the reach of even moderate instruments. Minute as the object is, how much it reveals to us of the wonderful mechanism of the universe! It is now an excellent comparative test in conjunction with the more difficult ζ *Boötis*. Recently (1865·46) I have found that 111 of my achromatic will strongly elongate it, and 450 show a division equal to 0·4, if not 0·5, of the disc of B. In such comparisons as these, however, it must be borne in mind that the quality of the eyepiece is somewhat involved, as well as that of the object-glass.

42. 70 *Ophiuchi*. 5″·425. 104°·77 (not good), (1864·48). Demb., 5″·666. 104°·96 (1863·06). The distance continues to diminish, the angle to increase.

43. λ *Ophiuchi*. 1″·777. 23°·4 (not good), (1864·45).—Demb., 1″·442. 19°·61 (1862·93). Motion very obvious.

47. $\epsilon^1$4 and $\epsilon^2$5 *Lyræ*.—ϵ^1, 3″·295. 19°·8 (1864·45).—Demb., 3″·045. 19°·35 (1863·09).—Secchi, 3″·07. 22°·42 (1856·24).—Struve, 3″·084. 26°·06 (1831·44). Angular

motion may be clearly recognized.—ϵ^2, 2″·455. 142°·7 (1864·45).—Demb., 2″·479. 143°·97 (1863·09).—Secchi, 2″·576. 148°·4 (1856·06).—Struve, 2″·573, 155°·17 (1831·44). Movement in both senses is still more evident here. The 9·5 mag. star keeps its relative position.

59. χ *Cygni*. Stationary; if the angle is not very slowly decreasing.

104. γ *Leonis*. 3″·387. 112°·93 (1864·31).—Demb., 2″·857. 109°·29 (1863·28). The results of different observers are still discordant, and the period must be very uncertain.

106. ξ *Ursæ Majoris*. 2″·568. 95°·42 (1864·2).—Demb., 2″·557. 96°·66 (1863·23). The distance appears to be again decreasing since Secchi's measure, 1857·357.

112. 72 P. II. *Cassiopeæ* (ι of Eng.). A and B, 2″·38. 267°·4 (1864·93).—Demb., 1″·927. 265°·87 (1862·99). Here Engelmann's measure (of a single night) is much less satisfactory than Dembowski's, reversing the diminution of the angle (as to which there is little doubt), and giving rather a *jump* to the distance.

Dr. Engelmann's mean values have always been cited. But it ought to be stated that, with the exception of *Castor* and ξ *Ursæ Maj.*, they are drawn from very few observations, and those not always very accordant; not unfrequently exhibiting only the result of a single night. And how liable such results are to further correction, all star-measurers know. Dembowski's have greatly the advantage in being deduced from a much larger number of observations. Still, every contribution is of value, and it is evident that truth will only be attainable through the means of a great amount of evidence, some of which must be expected to be of a conflicting character. Of this we have full proof in the recent observations at the Radcliffe Observatory, Oxford. It has been announced as the result of an examination, in 1863, of many of the stars in the Dorpat Catalogue, that they do not exhibit that degree of motion which Struve had concluded and anticipated. Deduced by means of a heliometer, the largest, or one of the largest in the world, and sustained by the *prestige* of a Greenwich reputation, the Oxford observations have a strong claim to be heard; and England loves fair play. But Struve has, and will have his supporters; and it is obvious that the matter ought to be fully gone into. That very considerable discrepancies exist is well known to all who search into the records of Double Star observations. But we have no right to wonder at the fact, when we consider that 1″ of arc is a very large value in these inquiries, and yet that quantity would be represented by about $\frac{1}{1000}$th of an inch in the focus

of an 18-feet telescope, or $\frac{1}{3000}$th in a 6-feet, so that, all the diversities and imperfections of instruments and of sight and of judgment considered, the real wonder is, not that there should be so much discrepancy, but that there should be so much agreement, in the results. It is obviously a question of testimony, and can only be decided by the patient accumulation and judicious selection of materials. All, therefore, who possess the means of measurement should endeavour to turn them to good account in the cause, and though the rough attempts of beginners can only give approximate results, yet we must remember that there was a time when Struve, and Smyth, and Dawes, and Secchi were beginners.

CRIMSON STAR.

Independently of its connection with our recent remarks on the colours of stars, the following striking object will be found worthy of a search from its intrinsic beauty. In p. 115 of our Vol. vi. mention has been made of Crimson Stars, but no especial instance was given. Such an one has, however, been obligingly pointed out to me by Mr. Knott, the first known recorder of its colour, in Oct., 1861, though not the discoverer of its existence, as it stands No. 1442 in the 18th hour of R.A. in Weisse's edition of Bessel's Zones. Observers whose instruments are provided with circles will hit upon it in R.A. 18h. 57m. 11s., D.S. 5° 53′; but it may be readily found without such assistance by means of its neighbour 12 *Aquilæ*. That star has been mentioned in p. 116 of our volume already cited, as the nearest of two a little *sp* λ *Antinoi*, the latter being a 3-mag. star, easily recognized from its position immediately *nf* the upper part of the hazy brightness of *Sobieski's Shield;* it is, in fact, the brightest for a considerable distance round it, and has only one competitor, δ *Aquilæ*, along the track of the Milky Way, between itself and *Al Tair*. Its next *sp* neighbour, 12 *Aquilæ*, 6-mag., having been identified, and placed in the centre of the field, we must sweep steadily on the parallel to the E. Having passed several small stars, barely exceeding 10-mag., which are plentiful in this region, we come to a star about 8-mag., having (if the field is a large one) on the N. an irregular line of three brighter stars lying nearly E. and W., and another brighter star *sf*. We then sweep on as far again in the same parallel to about 40′ of arc from 12 *Aquilæ*, when we come upon our object standing conspicuous among several very minute attendants. Its aspect is singular and striking, especially as contrasted with its whiter neighbours. The disk is of a rather feeble red, the intensity of light serving, perhaps, to make its

peculiar hue less evident—an effect which I have noticed in other deeply-coloured stars; but the surrounding rays are of a decided crimson cast. It is very much to be regretted that though it is rated by Knott as 7·3 mag., and consequently rather larger than the generality of such objects, it must be far below any full or satisfactory spectrum analysis. Perhaps some future time it may by reached with an aperture such as those of Lassell or Lord Rosse: and we may then expect some strange, though not improbably unintelligible, revelation as to its constitution. We cannot picture to ourselves the state of affairs consequent upon our being brought under the influence of a crimson sun; but we may conjecture that its effect upon a planetary system, if such surrounds it, must involve a very different constitution of things from anything within our solar bounds.

The star is readily visible, though of course not its hue, in a finder of little more than one-inch aperture. It seems remarkable that it should not be included in the list of Ruby Stars given by Sir John Herschel as an appendix to his Cape Observations, especially as the majority of his objects are of smaller magnitude.

REMARKS ON SATURN.

BY RICHARD A. PROCTOR.

Mr. Richard A. Proctor, of Stoke, Devon, author of *Saturn and its System*, reviewed in our last number, sends us the following:—

"Will you permit me to discuss, briefly, one or two remarks in your notice of my little work on Saturn? I wish to examine—first, the supposition that Saturn's rings may be vaporous; secondly, the opinion that the satellite theory is inadmissible in the case of the dark ring. Before doing so, however, let me observe, in answer to your remark that you 'would have been altogether better pleased with a fuller system of reference to original authorities,' that (excepting, of course, much that may be considered common property) I can conscientiously claim as my own every sentence, opinion, or calculation in *Saturn* which is not distinctly referred to an authority.

"The hypothesis that the rings are vaporous, may, I think, be very easily overthrown. Bessel calculated the weight of the rings to be $\frac{1}{11}$th part of Saturn's weight. The volume of

the rings (accepting Bond's estimate of their thickness) is less than $\frac{1}{3\,1\,0}$th part of Saturn's volume. Hence, the mean density of the system is more than double Saturn's mean density—or exceeds, by more than one-half, the mean density of water. Add to this the general permanence of the rings' form, and their power of intercepting and reflecting light (for the planet's shadow on the rings proves they are not self-luminous), and the idea that the rings are vaporous may safely be dismissed.

"The 'circumstance that the inner edge of the bright ring is' generally 'clearly distinguished from its darker neighbour,' is accounted for at p. 126 of *Saturn*. The objection drawn from the appearance of the dusky ring where it crosses the ball of the planet appears, at first sight, more formidable. It would, no doubt, require a powerful telescope to detect 'a thinly-scattered stream of light-reflecting satellites in front of the ball, supposing the latter uniformly illuminated. But we must not forget that each satellite, thus placed, casts upon Saturn a black shadow. Now, when the rings are open, the inner edge (even) of the dusky ring is more than 10,000 miles from the part of Saturn apparently behind that edge. Thus it may easily be shown, that if the line of sight from the observer to a satellite is inclined 10″ to the line from the sun to the satellite, the apparent place of the satellite on Saturn's disc would be removed half a mile from the shadow of the satellite. Hence, remembering that the satellites composing the ring must be very small, that the equatorial horizontal parallax of Saturn in opposition is 1″, that Saturn's disc in opposition subtends an angle of 19″, that when Saturn is in opposition lines from Saturn to the earth and sun may be inclined to each other in an angle as great as 2° 45′, while when Saturn is in other aspects the corresponding angle may be as great as 6° 23′, it is clear that nearly all the satellites are at all times shifted from coincidence with their respective shadows, and thus the black-spotted background of the disc is revealed. Hence, as the shadows (like the satellites) are not separately visible, the stripe of the disc crossed by the ring presents the observed appearance—dusky, but not nearly so dark as the other part of the ring, because the background is not black, but merely strewn with black spots.

"The fact is, that although, no doubt, 'it is extremely difficult to form any idea of the real nature of the rings from observation,' yet, in the present state of science, the system is far from 'offering a wide field for the admission of dissimilar theories.' The rings must be solid, fluid, or vaporous, and either continuous or discontinuous. I have shown that the idea that they are vaporous must be rejected, and absolutely insuperable dynamical reasons compel us to reject the idea that

they are solid or fluid continuous bodies, or composed of separate rings, however numerous, and whether solid or fluid. Hence it follows that the system is composed of separate bodies, necessarily small, since otherwise they would be separately visible.

"I may remark, in conclusion, that I am *very* far from claiming for my work the character of 'an exhaustive monograph;' but I think some of the observations referred to as not noticed in *Saturn* are referrible to disturbances of the earth's atmosphere, rather than to peculiarities in the physical condition of Saturn's system."

[We think that Mr. Proctor has quite misconceived our meaning with regard to "reference to original authorities." We have no idea whatever that he has not made the most perfectly warrantable use of his materials, or that he has in the least attempted, or wished to attempt, to take credit for anything not justly his own. But it is not so easy as it might have been, and as we should have preferred, for his own sake as well as his readers', to ascertain what his materials were. We always consider it matter of regret when writers of merit, in treating of subjects requiring accuracy, and involving possible differences of opinion, do not indicate explicitly the sources of their information; it is scarcely fair even to themselves, as exposing them in some cases to remarks which may possibly have no foundation, but for which, as arising from their own reticence or indistinctness, their readers are not to blame.

With regard to the idea of a possible vaporous constitution of the rings, which did not originate with us, and which we are not much concerned to defend, we may observe that Mr. Proctor's conclusion can have no greater force than his weaker premises, which assumes, what we are not disposed to admit, that the materials of the Saturnian system, and their modes of existence, are more similar to our own than has ever yet been demonstrated—we may perhaps add, are ever likely to be. We know absolutely nothing of the possible density of vapour there, the substances which may compose it, or the conditions under which it may subsist. As to the power of intercepting and reflecting light, it seems to us to present no obstacle. A mass of dense terrestrial cloud in the position of the ring would, we believe, be found fully as luminous, and its shadow equally obscure.—So again, in giving Mr. Proctor great credit for his solution of our difficulty as to the appearance of the dusky ring across the ball, we cannot say that it appears entirely satisfactory to us. The introduction of the shadows of the satellites is very ingenious; but though we admit that those shadows would seldom be hidden by the bodies that produced them, we think that, considering the multitude of

satellites required in order to make the ring visible at all, a large proportion of the shadow would still be always concealed from us by the interposition of satellites, though not of the individuals which caused them, and that the "black-spotted background" would be much less visible than observation shows, through the luminous stream. And even if, for argument's sake, we were to admit that every shadow contributed its visible share to the dusky appearance, we should only shift the difficulty; for the satellites ought to be at least as visible upon the sky, as their shadows upon the ball; which is entirely contradicted by experience. We will nevertheless suggest, in Mr. Proctor's favour, that possibly this objection might be somewhat mitigated by the supposition that these satellites may have a reflective power so inferior to that of the ball that they may be projected as dark spots upon it, as those of Jupiter frequently are when in transit. We have no wish, however, to prolong the discussion, but still believing, as we venture to do, that there is abundant room "for the admission of dissimilar theories," we wish nothing further than a free ventilation of the subject, and fair play for all. As to the probability that the details not noticed by Mr. Proctor may be referred to "disturbances in the earth's atmosphere," we hope that our readers at some future time will have an opportunity of forming their own opinion from a detail of the original observations.]

LITERARY NOTICES.

Sea Fishing as a Sport; being an account of the various kinds of Sea fish: how, when, and where to catch them in their various seasons and localities. By Lambton J. H. Young. (Groombridge and Sons.)—The numerous class of sea-side visitors who are fond of boating, and the possessors of yachts, will find this a very handy book. Mr. Young describes the various kinds of apparatus required for sea-fishing, and gives simple directions for their employment. Then follows a chapter on "baits," and a third on "fish," in which there is a compendious account of nearly every object which the fisherman is likely to seek. This part of the work is judiciously condensed, so that a marine sportsman can readily find the information specially necessary for his craft. The work closes with a brief history of sea fisheries. Mr. Young regrets the discontinuance of the collection of statistics of English fisheries since 1850, and recommends the employment of the coastguard and custom-house officers for that purpose. Few persons are aware of the immense importance of our fisheries, not only as a means of procuring food, but as supplying an excellent employment for our seaboard popu-

lation. In 1859, Mr. Young, quoting the returns, says—"12,802 boats, manned by 43,062 fishermen and boys, were employed in the herring, cod, and ling fisheries, and the total estimated value of the boats, nets, and lines employed in these fisheries was £739,096." Many important questions relating to the habits of fish can only be elucidated through the systematic collection of a great mass of information, and this is a kind of labour which the Government should undertake; but there is ample room for individual exertion, and if a larger portion of those who are addicted to maritime recreations could be inoculated with scientific tastes, much good might be achieved. At present we are totally ignorant of the causes of good and bad seasons for herrings and many other fish, and it is most desirable that efforts should be made to explain the reasons of their visiting or deserting particular localities. "Sea Fishing as a Sport" is a handsomely-printed volume—not too big for the pocket, with ample margins, and plenty of headings, so as to adapt it for quick reference. It is also furnished with eight well-executed plates of fishing-vessels, tackle, etc., not the least interesting of which are numerous diagrams of knots, in which the mystery of the ingenious fastenings in which sailors delight is clearly explained.

A History of British Ferns. By Edward Newman. The fourth, or school edition, with plates and glossary. (Van Voorst.) —We welcome a cheap edition of Mr. Newman's ferns, but we do not understand why it should be called a "school edition," as it is not likely that any number of schools will take up the fern family as a specialty in their course of instruction. Elementary instruction in systematic botany ought to form a recognized branch of ordinary education, and pupils fairly taught would then be prepared to pursue any particular branch of the study to which their interest might be excited. Mr. Newman's merits as a writer on ferns have always been acknowledged; but he is not entitled to treat all other writers as merely copyers of what he has done. His book is a valuable one, and the issue of a cheap edition will induce a great many admirers of ferns to become purchasers; but we think some other writers have arranged their descriptions in a manner more convenient for quick reference in practical use. Mr. Newman's mode of numbering the objects in his plates is exceedingly good. Every fern is described in order, with a number prefixed, and that number marks the position of the corresponding figure in the plates. His directions for the cultivation of various kinds of ferns will especially commend his volume to many families who delight in this elegant mode of decorating their abodes.

A Dictionary of Science, Literature, and Art: comprising the Definitions and Derivations of the Scientific Terms in general use; together with the History and Descriptions of the Scientific Principles of nearly every branch of Human Knowledge. Edited by W. F. Brande, D.C.L., F.R.S., L. and E. of Her Majesty's Mint; and the Rev. George W. Cox, M.A., Late Scholar of Trinity College, Oxford, assisted by gentlemen of eminent scientific and

literary acquirements. Part V. (Longmans.)—The good opinion we formed of this work (physiology excepted) is confirmed as it goes on. It will be a very valuable book for general reference. The present part (V.) begins with G, gets as far as I, as Iguanadon.

Homes Without Hands. By the Rev. J. G. Wood, M.A., F.L.S. (Longmans.) Part XIX. contains the usual variety of interesting matter. The frontispiece exhibits the albatross with its nest. The other illustrations are excellent, and the letter-press ranges from the homes of various insects to those of mice. Part XX., which completes the work, commences with a striking landscape picture of the elk. Moths and birds, besides the elk, occupy its pages; and although throughout the work the arrangement is not technically scientific, it has assisted the author's purpose of providing varied and entertaining reading.

For and Against Tobacco. By Benjamin Ward Richardson, M.A., M.D., Senior Physician to the Royal Infirmary for Diseases of the Chest. (Churchill.)—Dr. Richardson embodies his researches into the action of tobacco on the human frame, in a stout pamphlet, containing a great deal of interesting matter, and yet not quite satisfactory, partly from the difficulties naturally pertaining to the subject, and partly from his not adequately discriminating the different effects of large and small doses of the fumes which smokers take into their mouths. Watery vapour, free carbon, ammonia, carbonic acid, and an oily product composed of nicotine, a volatile substance of an empyreumatic odour, and a bitter resinous extract, are the substances which he finds in tobacco smoke. The quantity of these materials taken into the system will depend upon the quality of the tobacco, and the mode of smoking it. One good Havannah cigar is found by Dr. Richardson to yield enough poisonous matter, when its smoke is condensed, to induce active convulsions in a rabbit, and six pipes of common shag tobacco yield sufficient poison to destroy a rabbit in three minutes. Before a smoker has got used to his occupation, the tobacco produces, as is well known, considerable discomfort and disturbance; and judging by comparison with what he has observed in lower animals, Dr. Richardson conceives the brain of the patient to be pale and empty of blood, his stomach to be reddened in round spots, his lungs to be as pale as those of a dead calf, his heart overburdened with blood and contracting feebly, "every fibre being impregnated with a substance which holds it in bondage, and will not let it go." After a few experiments, the unpleasant effects are moderated, and cease, the poisonous matter being eliminated by the skin, the lungs, and the kidneys. If the lungs are weak or obstructed, the smoker becomes saturated with the products of the weed, and not only his clothes, but his skin, diffuses odours that remind one of a concentrated extract of taproom, and which no nasal organ could commend. The volatile tobacco poisons escape by the skin and lungs, the nicotine and bitter extract enter the body in solution with the saliva, and are supposed to be discharged by the kidneys. "In the confirmed smoker there is undoubtedly a constant functional disturbance; *i. e.*, his organs are doing work which

is not essential to their duties; but they do it with moderate ease; they receive nothing that is deposited in their structure, and, let alone, they soon regain their natural condition. In the recognition of these simple truths, the whole gist of the tobacco controversy is enclosed; it is on the presence of the functional disturbance that the vehement anti-tobacconist bases his arguments; it is on the absence of organic mischief that the advocate of tobacco rests his defence." This is Dr. Richardson's philosophy of the whole matter; but while disposed to go a little way with the anti-tobacconists, we think it necessary to guard against supposing that every disturbance of function is necessarily a mischievous thing. This must, we imagine, depend on the amount of the disturbance, on its precise character, and on the state of co-ordination or the reverse in which the various functions previously existed. The red globules of the blood are found by Dr. Richardson to be much affected by smoking; "they lose their round shape, they become oval, and irregular at the edges, and instead of having a mutual attraction for each other, and running together—a good sign of their physical health—they lie loosely scattered before the eye, and indicate to the learned observer that the man from whom they were taken is physically depressed or deplorably deficient in muscular and mental power." Dr. Richardson tells us that these remarks result from direct observation of the blood of smokers in every phase of *poisoning* by tobacco, and he believes they fairly represent the action of tobacco on the blood. But is it right to assume that moderate smoking in persons that are seasoned to its influence really *poisons* them at all? Is it not more probable that the functional changes it effects are in many cases beneficial? Dr. Richardson explains how rapidly the poisonous effects may pass away; but if a hard-working man smokes his pipe, and feels refreshed by it, is it correct to suppose that his resumption of labour is an indication that he has recovered from a mild attack of poisoning? What proof is there that he has been poisoned at all? Tobacco is admitted by Dr. Richardson to have "the property of checking the oxydation of the body, and thus of diminishing waste;" and if so, there must be occasions for its use in appropriate quantities, to which no poisonous action could be ascribed. Many of the charges against tobacco are rejected by Dr. Richardson on what appears good grounds; but he thinks it prone to occasion a peculiar disorder, described by Dr. Gibb as the "smoker's sore throat," of which enlargement of the tonsils constitutes one symptom. In consumption and chronic bronchitis, Dr. Richardson finds smoking decidedly mischievous; and on the whole, he regards it as "a luxury which any nation of natural habits had better be without;" and he adds, "I do not hesitate to say that if a community of youths of both sexes, whose progenitors were finely formed and powerful, were to be trained to the early practise of smoking, and if marriage were to be confined to the smokers, an apparently new and physically inferior race of men and women would be bred up." With this we thoroughly concur, and think that any rational parent would desire to prevent boys from smoking, just as they would object to their beginning life with dram-drinking.

Bad as Dr. Richardson thinks of tobacco, he regards it as less hurtful than alcohol or opium, and no worse than *tea and sugar*. With this comfort, the smokers will feel able to enjoy their pipe, because, bearing due reference to the conditions of modern civilization, very few scientific men would venture to assert that the moderate use of all stimulants, or of sugar, is detrimental to health.

ARCHÆOLOGIA.

A VERY remarkable TUMULUS called BELLER'S NAP, in the parish of Charlton Abbots, in Gloucestershire, has recently been excavated by Mr. W. Lawrence, F.S.A. It is one of those tumuli commonly known as *long barrows*, being of great length and elevation, and it is situated upon high ground in a secluded district. Mr. Lawrence's careful researches show that it had been constructed over four distinct chambers, each formed of very large stones. These chambers contained human skeletons, but unaccompanied with urns, weapons, or other objects. The huge mound was composed of stones, in the removal of which, not effected without great labour, some few fragments of pottery were found, which appear to be Roman, or Romano-British, which means nearly the same thing. The discovery of these fragments has suggested to some that the mound had been, at some former period, opened and the chambers rifled, but it was the opinion of the excavators themselves, and they were probably correct, that this was not the case, and that the barrow had not previously been disturbed. Some of the skulls were sent to Cheltenham, to be examined, it was said, by a craniologist. One of the original entrances to the mound is very imposing, from the height and peculiar construction of the walls, which commence at a considerable distance within the mound, and extend on each side outwards, sweeping round and gradually diminishing until they are only about a foot apart. They are composed of laminæ of the peculiar slaty stone of the district, laid one over the other, and resembling, in many respects, the walls, or fences, of the fields, except that the former are built of smaller stones. Mr. Lawrence is, we understand, preparing plans and drawings for a detailed account of this discovery, which is to be laid before the Society of Antiquaries during their next session.

Excavations made by Mr. Farrar in CHEDWORTH WOOD, Gloucestershire, promise to lead to interesting discoveries. The foundations of a very extensive ROMAN VILLA are being brought to light; some of the rooms have tessellated pavements; and there is a suite of baths provided with water by a reservoir of stone supplied from a spring. This part of England appears to have been, in Roman times, remarkable for the number and splendour of its villas.

A very interesting ROMAN VILLA has also been excavated on an estate of Lord Eldon, about eight miles from Cirencester. It is

situated on the slope of a hill. Its extent may be imagined from the fact that upwards of thirty rooms have been already traced, three of which have good tessellated floors, and it has three baths. An Archæological Society has printed a paper on the subject of this villa, the writer of which suggests that it was the palace of the "king of Britain," Arviragus, who, perhaps, never lived anywhere but in the fabulous history compiled by Geoffrey of Monmouth.

The age of the introduction of PAPER into Western Europe in the Middle Ages has recently been a subject of considerable discussion, but unfortunately among scholars not very profoundly acquainted with the subject. Paper was, of course, common in England throughout the fifteenth century, and it was in use, though it was then much rarer, in the latter half of the fourteenth. We then find books made of leaves of paper intermixed with leaves of vellum, which, perhaps, shows that there was not much difference in value between the two articles. The last portion of the Surrenden library, collected by the Kentish family of the Derings, and recently brought to the hammer, contained what is described as "evidence of five marks of rent to Cobham College," forming a small roll of paper, and said to have been written in the reign of Richard II.; and also an *inquisitio post mortem* on the death of John de Northwode, with an extent of the manor of Thurnham on paper, to which the date of 1319 is given. We are inclined to suspect that there is some error about the latter at least. Paper was, no doubt, brought into England from France, where it was in use at a rather earlier date. We remember a few years ago examining a few curious little documents in Paris; they were shown to us in the then Royal, now Imperial, Library, we believe by Champollion Figeac, and consisted of bonds for money lent to Crusaders, at the time of the Crusades under Richard Cœur de Lion, and the French St. Louis, and several of them were written on pieces of paper. We are not quite sure that any of the paper documents belonged to the time of King Richard, though we think that was the case; but they were certainly not more recent than the date of St. Louis's crusade. The paper appeared to be of Italian manufacture.

The researches of the geologists and naturalists in search of evidence of the antiquity of man, have given rise to many strange stories, and have unfortunately given a new impulse to the manufacture of *false antiquities*. Forged flint implements are now scattered about by bushels, and it is very difficult to avoid being deceived by them. Among the strange stories which have recently appeared is a statement published in one of the local French papers, to the effect that, in one alluvial deposit between Veyziat and Oyonnax, in the department of the Ain, a fossil man, four *mètres*, that is, rather more than thirteen feet in height, in a horizontal position, but "with his head downwards and his feet in the air." How so gigantic an individual came into such a singular position, appears not to admit of easy explanation, but the account is said to be authenticated by some apparently very respectable names.

The excavations at SILCHESTER continue to be carried on under

the direction of the Rev. Mr. Joyce, the incumbent, and at the expense of the Duke of Wellington, the lord of the land. Unfortunately, the covering of earth over the Roman level is here very shallow, in which case, as we might expect, the objects scattered about are less numerous than when the covering is deep, because the old floors, etc., have been longer bared to the view, and, therefore, exposed to depredation. Many Roman coins, implements in iron, and other such things, have, we understand, been gathered by the excavators, and the foundations, as far as yet uncovered, present many features of great interest. The Roman town appears to have been crossed by streets regularly laid out, as at Wroxeter; one tessellated pavement has been found in a tolerable state of preservation; and there can be no doubt that, as the excavations proceed, they will throw more and more light on the condition of Britain under the Romans. T. W.

PROGRESS OF INVENTION.

Non-Explosive Gunpowder.—It has long been known that filling up the interstices between the grains of gunpowder, prevents or retards its explosion—room being no longer left for the expansion of the gases which are evolved, as the grains ignite one after another in rapid succession. It is not necessary that the substance used to produce this effect should be non-combustible, since even gunpowder itself, in a state of minute subdivision, greatly retards the explosion of that which is granulated. Some materials would be inadmissible as preservatives against the accidental explosion of gunpowder, because they absorb moisture, others because they would injure the glazing. Sand is liable to both these objections; and most probably glass, since it must scratch the grains, and in the course of time it becomes alkaline, consequently hygrometric. It is indispensable that any substance mixed with gunpowder to protect it should be easily and thoroughly removable, though not spontaneously. Now it is doubtful if any mixture of the kind would remain complete during carriage; and it may be proved, by using a white powder, that a sieve would not effect a perfect separation—while, unless the protecting powder is completely removed from the gunpowder previous to use, its goodness would be seriously impaired. Mr. Gale, a chemist, of Plymouth, has recently made experiments on this subject, which have attracted considerable attention; chiefly, perhaps, because it was not generally known that gunpowder has long since been rendered inexplosive by means identical with those used by him, but which have not been adopted in practice, on account of the objections to which they are liable. M. Piobert, of St. Petersburg, made experiments with inexplosive powder in 1835, and M. Fadeieff between 1840 and 1844. M. Piobert, among the various substances which he tried, found that each of the constituents of gunpowder itself would answer well;

but he preferred a mixture of charcoal and graphite, as not in the least hygrometric. Mr. Gale uses powdered glass. When an equal quantity of this is mixed with gunpowder, the explosion resembles that of a squib, and the effect is nearly the same when one part gunpowder and two parts glass are used. Three parts glass entirely prevent explosion; and, with four parts, even a red-hot poker produces no effect. When unprotected gunpowder is exploded in the midst of that which is protected, the latter is merely scattered. M. Piobert used only enough of the foreign substance to prevent the gunpowder from being dangerous. The objections against any protective medium are serious; the comparative cheapness of carriage with non-explosive powder would, no doubt, compensate for its greater quantity; but the processes of mixing and sifting would be dangerous, and in many cases objectionable; unprotected might be fatally mistaken for protected powder, and the very process of mixture would most probably cause a deterioration which could not be permitted. The project, on the whole, appears to be one of those which are extremely plausible only until carefully examined.

Nitro-Glycerine.—This highly explosive compound has been lately applied, by M. Nabel, a Swedish engineer, with great success, in mining. It was discovered in 1847 by M. Sobrero; but until now was not applied to any useful purpose. It is far less costly than gunpowder, though four times stronger. It requires no tamping, and may be used where, on account of the dissipation of the gases produced by the explosion of gunpowder, the latter would be ineffective. When the hole formed in the rock is sufficiently deep, any fissures which may have been discovered in connection with it are to be stopped with clay, to prevent the escape of the nitro-glycerine. The latter may then be poured in, and after it water, which will float on its surface: a slow-match, having a percussion-cap at the end, is next introduced into it. During some experiments that were made in blasting a dolomitic rock, a litre and a half of the nitro-glycerine, placed in a hole seven feet deep, and ten from the outer face of the rock, produced two great fissures, one fifty and the other twenty feet long; and three-quarters of a litre, in another case, poured into a similar hole, threw down about one hundred cubic metres of the rock. With nitro-glycerine, the expense is only one-half as much as with gunpowder, to produce an equal effect.

Electricity the Cause of Animal Colours.—M. Nicolas Wagner has recently brought before the Academy of Sciences experiments which seem to show that electric currents are the cause of the colours, at least of some animals. These experiments were made on the nymph of a species of diurnal butterfly (*Vanessa urtica*). Electric currents changed the reds into orange, and the blacks into red; and the most feeble current, especially if from a constant battery, produced black spots, the shape of which had a relation to the current. He ascertained, by means of an extremely sensitive apparatus, that not only does electricity modify and even produce colours, but that those found in the butterfly are

due to currents in the wing of the animal—the most energetic of which issues from the base of the wing, and follows the middle nervure till it reaches the outer edge.

VENTILATION OF SEWERS.—M. Robinet, a French chemist, proposes to ventilate sewers by causing the air required for combustion in factories to be obtained from them. According as the impure air is taken away by the draught of the furnaces, pure air will rush in from the atmosphere. He calculates that the Parisian sewers would be emptied of their contents many times a day, even though only some of the furnaces in that city were thus supplied with air. The sewers are a source of great danger in this country, also, from the noxious effluvia they emit, and which but too often find their way even into dwellings. There is no reason why a means of ventilating them so simple and effective should not be adopted.

ETCHING IN RELIEF.—M. Boettger has lately invented a simple process for this purpose. The drawing is made with a quill on clean polished zinc, with a solution containing one part dry chloride of platinum, and one part finely powdered gum arabic, in twelve parts, by weight, of water. Before the writing is quite dry, the plate is immersed for a few moments in a solution of aurocyanide of potassium, which covers it over with a thin coating of gold. It is then placed in a liquid containing one part nitric acid, spec. grav. 1·2, and sixteen parts water, and rubbed with a camel's-hair brush. The gold peels off, except in the places covered by the lines of the drawing; and, after some time, the hollows will have become sufficiently deep for the plate to be used in printing.

DANGER FROM CONTACT WITH A PERSON STRUCK BY LIGHTNING.—It might be supposed that, when any one is struck by lightning, the electric fluid immediately passes away, on account of the conducting power of the animal body, and of the objects in contact with it, especially if moisture is present. This, however, does not always occur; though our present knowledge of the laws of electricity will not suffice to explain the exceptional cases. Two instances illustrating this subject have been brought before the Academy of Sciences by M. Boudin. One occurred on the 30th June, 1854. A man was killed in the *Jardin des Plantes* at Paris, by lightning, and his body was exposed for some time to heavy rain. When, however, two soldiers attempted to remove it, they received, the instant they touched it, a very violent shock. The other happened on the 8th September, 1858. Two artillery men, at Zara in Dalmatia, were appointed to remove telegraph posts; on attempting to lay hold of them after a violent thunder-storm, they were thrown down and greatly injured, especially one of them. When a comrade endeavoured to assist him that was most hurt to rise, both were dashed violently to the ground; the comrade was burned in the arm, and was afterwards affected with nervous symptoms.

THE SENSITIZING OF IODIDE OF SILVER.—The different deportment of iodide, under the action of light, from that of other salts of

silver, has long attracted the notice of chemists and photographers; but the reason of this difference, though involving very important considerations, has not been hitherto understood. Even unexplained facts are valuable, but an explanation very often renders them infinitely more so. Such is the case with regard to the peculiarity of iodide of silver. Dr. Vogel, of Berlin, has recently thrown a new light on the conditions which render this salt sensitive, or the contrary. It was long known to photographers that iodide of silver, formed with excess of iodide of potassium, is totally insensitive to light; but that, when the nitrate has been left in excess, it is highly sensitive. In looking for the reason of these facts, it occurred to him that certain compounds are decomposed immediately by heat, while others, in addition, require the presence of a body that has an affinity for an element which the heat will set free. Thus, heat by itself will decompose oxide of silver, but it will not decompose oxide of iron, unless hydrogen is present to unite with the liberated oxygen. The consideration of this difference in the powers of heat led him to suspect that the action of light might be analogous; that, by itself, it might decompose some compounds, while it would have no effect upon others, except in presence of a body which could unite with an element it should disengage; and further inquiry showed that he was right. Here then was found an explanation of the apparent anomalies connected with the salts of silver. The chloride, for instance, is decomposed by light alone; the iodide requires the presence of some substance that will combine with the liberated iodine: such a substance is found in nitrate of silver, and in tannin, bodies which, at first sight, would seem to have nothing in common. The principle once discovered, it was found to be susceptible of very extensive application; any substance ready to combine with the liberated iodine will answer instead of the nitrate of silver, or the tannin. It is chiefly the excess of nitrate, present in wet plates, that renders them more sensitive than those which are dry; but such a substitute for nitrate of silver may be found as will impart an equal sensitiveness to dry plates—one of the greatest boons that could be conferred on the photographer.

Enamelled Silver.—The art of enamelling is very ancient; its products are both very beautiful and very durable. Its utility has, however, been circumscribed by various circumstances, among which is to be reckoned a restriction as to the material on which the enamel is produced. This has usually been copper or gold: the former is objectionable for several reasons, the latter from its dearness. Silver would be a very appropriate material; but, until recently, it was not possible to use it in enamelling. M. Auguste Geffroy, of Paris, has, however, after a long series of experiments, discovered the means of employing it for the purpose, and intends very shortly to make known the causes which have led to the failure of others, and to his own success.

Improvement of the Air-pump. — Certain imperfections are observable in the ordinary air-pump which, hitherto, it has been

found impossible to get rid of. Among these is a great friction between the piston and the barrel, and, worse still, the disarrangement of the valves, on account of the oil used for lubrication getting into them. M. Deleuil believes that he has avoided these, in a new form of pump, which will answer at least for those industrial purposes in which only a moderate vacuum is required. Strictly speaking, it is but a modification of the hydraulic pump, to which we have already directed the attention of our readers.* The piston, which so nearly fills the barrel that only a sheet of paper can be inserted between them, is of a length equal to twice its diameter, and has grooves on its surface distant from each other about four-tenths of an inch. When this piston is moved backwards and forwards in the barrel, even with moderate rapidity, a vacuum equal to from three to seven inches of mercury is produced in a comparatively short space of time. As the air drawn from one direction may be forced onwards in the opposite, the apparatus may be used as a condensing pump, so as to produce a pressure of about two atmospheres.

New and Simple Mode of Reproducing Drawings, etc.—The drawing having been made with a solution of gum, glue, varnish, or any other fluid which will impart hardness, it is transferred to a plate of plaster of Paris, chalk, or anything else that is easily pulverized. This plate, having been allowed to dry, is brushed until the material between the lines of the drawing—which is not affected by the process—is removed to a sufficient depth: after which it is immersed in gum, or glue, to harden the entire surface. The result is an admirable copy of the drawing in relief, and from this a *fac simile* in metal may be obtained in the usual way.

Miscellaneous.—*Photography in the Dark.*—If a sheet of paper, prepared with a solution containing 400 grains of isinglass, 440 grains of iodide of potassium, 146 grains of bromide of potassium, 54 grains of chloride of sodium, and 40 ounces of water, though it is not sensitive to light, is placed upon a picture, and another sheet beneath it, and they are left in contact for some time in the dark, the upper sheet will be found to contain a negative of the picture, and the lower a positive, in which the light greens and blues will be represented by white, and the reds by red. It has not yet been found possible to fix these.——*Roofs on the principle of Suspension Bridges.*—M. Lehaître, a French civil engineer, proposes to construct roofs having a span very far greater than any hitherto attempted, by supporting them with suspension cables. They will have an advantage over suspension bridges, in being free from the injurious effects produced by varying loads.——*Origin of Diamonds.*—It has recently been shown by Professor G. Oppert, with great probability, that diamonds are the result of the decomposition of vegetable matter. They often contain, on their surface, impressions of grains of sand, etc., and within them, fungi, and other organic bodies. This could not be the case if they were formed at a high

* Intellectual Observer, No. xxxvii. p. 78.

temperature—under which, indeed, they become black.——*Gun Cotton as a source of Motive Power.*—M. Jules Gros has invented an engine, in which motive power is derived from the gases evolved in one reservoir by the explosion of gun cotton, and condensed in another.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

GEOLOGICAL SOCIETY.—*June* 21.

Mammalian Remains found near Richmond, Yorkshire.—Mr. Boyd Dawkins described some mammalian remains, discovered last autumn on a terrace of blue clay, mixed with limestone débris, about 130 feet above the north bank of the river Swale, during excavations for a new sewer. The deposit appears to be a heap of kitchen refuse, the great majority of the bones being broken, while not one of the numerous skulls is perfect. The collection contained bones of the following species:—Bear, dog, pig, horse, red-deer, fallow-deer, sheep, *Bos longifrons*, *Bos brachyceros*, *Capra ægagrus*, and the horn-cores of a form of goat, which appeared to be the *Ægoceros Caucasica*, which had also been found by Mr. Dawkins and Mr. Sanford in a bone-cavern explored by them in 1863. M. Lartêt has expressed his opinion that these horn-cores belonged to some of the diversified forms that are the result of hybridity, and stated that they resembled some found in a bone-cave in the Pyrenees, which appeared to belong to a hybrid between the goat and the Bouquetin.

ZOOLOGICAL SOCIETY.—*June* 27.

Pigmy Fossil Elephants of Malta.—Mr. Busk communicated an account of his examination of the collection of fossil elephant bones made in Malta by Captain Spratt, R.N. These bones include the remains of three perfectly distinct species. One was nearly equal in bulk to the existing Asiatic species, and was probably referable to *Elephas Antiquus*. The others were remarkable for their diminutive stature as compared with the existing species of elephant. Neither of them exceeding the height of five feet when full grown. It might be imagined that the remains were those of young animals, but an attentive examination proved that their ossification had been perfectly completed, and that they consequently belonged to full-grown and perfectly mature individuals. Both these small species are distinguished by very well marked differences in their dental and osteological characters. The existence of a race of pigmy elephants in a European island is a circumstance of considerable interest, geologically as well as zoologically considered.

In connection with these elephantine remains from Malta, the arrival of a living specimen of the African elephant at the gardens of the Society in the Regent's Park may be noticed. The African elephant is perfectly distinct from its Asiatic congener, the structure of the molar teeth in particular being extremely different. The animals when living are readily distinguished by the immense size of the external ears in the African variety, these organs meeting on the upper part of the skull, and covering the entire scapular region and anterior part of the body. As both the Indian and African species now exist in the gardens, a very favourable opportunity is afforded of contrasting the striking differences between the two animals. Amongst the most strongly-marked distinctions is the difference in the formation of the prehensile organ at the end of the trunk in the two species. In the Asiatic this organ is usually compared to a flexible finger acting against the septum between the two orifices at the end of the trunk. In the African animal the end of the trunk appears divided horizontally, so that the upper and lower parts are of nearly equal size and power, and act against each other, opening and closing somewhat like a pair of pincers.

NOTES AND MEMORANDA.

The Humming-Bird Hawk-Moth—*Macroglossa Stellatarum*.—Mr. C. S. Beckett, of Lyncombe Vale, Bath, writes:—Every year I have noticed an occasional visit from this attractive insect, and its peculiar habits have always excited fresh attention; but this summer, probably from the unusual warmth, has been marked by the arrival of numbers. My attention was first drawn to them one evening early in July, as I was contemplating a mass of jessamine in full bloom covering a rustic archway in our garden. It was twilight, and I felt much surprised at a whirring sound amidst the blossoms, and a busy scene, caused by no less than eight dusky-looking moths darting in and out of the branches. Their actions reminded me of my old favourite, but it was too dark to ascertain. Very near this starry mass a fly-catcher had taken up his station on a wall, whence he perpetually took airy excursions to capture invisible prey. I wondered he did not make a hunting-ground of the jessamine-bush; but probably he knew the moths were too sharp for him. The next morning I went to gather a large bouquet of jessamine, and to my satisfaction found four moths, no longer looking dusky, save the upper wings, but rendered rather attractive by the bright rust-coloured hinder wings, and bodies curiously tufted with white and black scaly hairs. They seemed little disturbed by me, and one even visited my bouquet, and most unceremoniously rifled the sweets of one flower after another as I held them in my hand, thus giving me an opportunity of closely observing its manœuvres, the vigilance of its hawk-like eyes, the accuracy with which it inserts its long, flexible proboscis into each flower, and its mouse-like head and body. Another day I watched it unerringly dip its needle tongue into the base of each petal of a carnation. It appears that the great length of this tube suggested the generic name: the specific name has nothing to do with this stage of its existence, but is derived from the stellate plants on which the caterpillar feeds, such as the Galiums. The caterpillar is inconspicuous, and probably not often noticed; but the perfect insect is so unlike the race of unobtrusive moths, that it well deserves attention, and many a quarter of an hour may be profitably employed and beguiled in watching the eccentric darting flight and habits of this lively little creature.

HEAT FROM ROTATION OF A DISC IN VACUO.—Mr. Balfour Stewart and Mr. P. G. Tait have been for some time engaged in very curious and important experiments on the heat acquired by the rotation of a disc of metal in vacuo. *The Proceedings of the Royal Society*, No. 76, contains a paper on this subject, from which it appears that a disc of aluminium, thirteen inches in diameter, was caused to revolve rapidly in a vacuum chamber. After moving for about forty seconds, at the rate of 2500 per second, a heating effect equal to 1° F. was indicated by a thermo-electric pile. The writers detail various reasons for believing that the augmentation of heat did not arise from the friction of the bearings, nor to "revolution under the earth's magnetic force," and they say that they are reduced to two possible causes—the friction of the air, which cannot be entirely got rid of in any artificial vacuum, or "the possibility that simple motion becomes dissipated by an etherial medium in the same manner, and possibly to nearly the same extent, as molecular motion, or that motion which constitutes heat," or the effect may be partly due to air and ether. It could not be due to air, because, in the first place, it was found not to be proportioned to the quantity of air left in the vacuum. Professor MAXWELL and Mr. Graham considered that the fluid friction of air was not dependent upon its tension, and therefore diminishing the quantity of air in the vacuum would not proportionally diminish the friction action. Hydrogen fluid friction is much less than that of atmospheric air, but when a hydrogen vacuum was employed, the heating effect was so nearly the same as in an air vacuum, as to offer a second reason for not ascribing the heating to this kind of action.

NEW MODE OF SALTING MEAT.—M. Pienkowski informs the Academy of Sciences (Paris), that acetate of soda leaves meat in a condition in which it may be easily dried, has a pleasant smell, and can be unsalted easier than when prepared with chloride of sodium.

LIVING BODIES AND LIGHTNING.—In our last number we mentioned the case of a flock of sheep and their shepherd being struck by lightning on the Ourthe. M. A. De la Rive, commenting on this incident in the *Archives des Sciences*, observes that an agglomeration of men or animals in the open air augments the danger of their being struck by lightning, either by accumulating a greater mass of conducting matter on one spot, or by giving rise to an ascending column of vapour down which the lightning descends. Sheep, he says, herd very close together when they are frightened, and would thus produce this effect in a striking degree. He recommends persons caught in a storm not to stand too near each other.

ALLEGED REMEDY FOR CONSUMPTION.—Dr. Schnepp of Eaux-Bonnes states in the *Presse Scientifique* that an excellent effect is produced in consumptive patients by a fluid he calls *galazyme*, which bears some resemblance to the *kumis* of the Tartars, to which they ascribe valuable qualities. He takes two parts of asses' milk and one of cows' milk, and allows them to ferment. The fluid thus obtained should be clear and sparkling. He gives one or two glasses a day for a commencing dose, and raises the quantity to one or more bottles.

THE COLOUR OF MARS.—*Monthly Notices* contains a paper on Mars by the Rev. W. R. Dawes. He concludes that the ruddy tint of this planet does not arise from any peculiarity of the colour of its atmosphere, as the redness is most apparent in the centre where the atmosphere is thinnest.

MOBILITY OF THE SUN'S PHOTOSPHERE.—Mr. Brodie observed on 10th May, 1864, a large oval spot in the sun, and fringed all round with beautiful filaments of luminous matter stretching over and towards the centre of the umbra. In the course of three and a half or four hours, an unusually wide bridge of luminous matter had formed completely across the spot; . . . the bridge of luminous matter was about 3500 miles wide, and being formed across the oval-shaped umbra, at some little distance from its minor axis, the length might possibly not have been more than 5500 miles at that point. This would give the enormous velocity of 1400 miles per hour to the luminous matter which formed this bridge."—*Monthly Notices.*

LIGHT ORGANS OF GLOWWORMS.—Professor MAX. Schultze states that in males of the species *Lampyris splendidula* numerous tracheal branches in the luminous organs terminate in star-shaped cells. Osmic acid rapidly tinges these cells black, while the cells of the parenchyma remain colourless. It is, therefore, evident that the cells of the trachæa have the property of rapidly abstracting oxygen from the osmic acid, which readily parts with it.—*Archives des Sciences.* It will be interesting for our readers to try similar experiments with our English glowworm.

ABSORPTION BANDS AND TEMPERATURE.—M. Feussner finds that chlorides of iron and copper, sulphate of copper, ammoniacal sulphate of copper, bichromate of potash, sesqui nitrate of nickel, proto-chloride of cobalt, and bichloride of platina, have their absorbing powers increased by heat. Chloride of copper in a suitable degree of concentration is completely opaque at its boiling point, and that portion of the spectrum which remains longest visible when the temperature is increased does not coincide exactly with that which is the last to disappear when the thickness of the layer is gradually increased. Chloride of cobalt at ordinary temperatures, and at a convenient degree of concentration, furnishes in the spectroscope two luminous bands, one of which, embracing all the red, all the yellow, and part of the green, is very intense, and the other of little brightness is situated in the violet. If heat is applied, the violet band diminishes in intensity, and two new bands, of which no trace previously existed, appear in the red. These bands increase rapidly in breadth, especially that which is the most refrangible, as the temperature augments, and when the boiling point is reached, they completely obscure the luminous band in which they are formed with the exception of a narrow and feeble ray at the extremity of the red.—*Archives des Sciences.*

TRANSPARENCY OF THE SEA.—Father Secchi communicates to the French Academy the result of experiments made by M. Cialdi, commander of the "Immaculate Conception" corvette, from six to twelve nautical miles off Civitta Vecchia, where the sea depths varied from 90 to 300 metres. A great disk 3m.73, or rather more than 4 yards in diameter, formed of an iron hoop covered with cloth, painted white, and provided with apparatus for keeping it horizontal, was sunk on a remarkably clear day, and ceased to be visible at a depth of 42½ mètres, or about 140 feet. The sun's height was 60° 17'. Had the sun been vertical, Father Secchi says the disk might have been visible six or eight feet deeper. Smaller disks lost form so much by refraction that they could not be seen at the depths at which the great one remained visible. As the large disk was sunk to different depths its colour became first slightly green, then light blue, after which the blue grew deeper, until it could not be distinguished from the colour of the surrounding water. Thus the disk did not disappear because the light emanating from it was not permitted to reach the eye, but because after the sunlight had penetrated to a certain depth in the clear sea, and came back again through the water, it had lost all rays capable of characterizing the disk, and the light reflected from the disk could not be distinguished from that coming from the water around it. Very large objects, such as portions of the sea bottom, Father Secchi thinks might possibly be seen at 50 or 60 mètres deep in a sea like the Mediterranean, but he thinks there must be a mistake in the stories of the sea bed having been recognized at depths of from 100 to 200 mètres.

ELECTRIC PROPERTIES OF MINERAL WATERS.—*Comptes Rendus* contains a note by M. Scoutetten on the electric condition of mineral waters. He states that such waters fresh from their source are in a state of chemical activity which gives rise to an active electrical current, recognizable by a galvanometer. He ascribes their curative properties to this exhibition of electricity. We would suggest that, if the electric state be as he describes, it does not follow that the curative action of the mineral water is directly dependent upon it. Very small quantities of chemical substances in a nascent state may, from the great facility with which they enter into new combinations, produce remarkable physiological effects, and electricity may have nothing to do with the matter excepting so far as is connected with chemical affinity.

Pottery from Upchurch, Kent.